Seeds of duck food plants. *Left to right, top row:* sago pondweed, softstem bulrush, American bulrush, Lophotocarpus, duck potato. *Second row:* pigweed, rice cut-grass, wild millet, Japanese millet, Walter's millet. *Third row:* chufa, marsh smartweed, swamp smartweed, largeseed smartweed, nodding smartweed. *Bottom row:* longleaf pondweed, buttonbush, American lotus, pickerelweed, giant bur-reed.

TABLE 1.—RELATIVE WEIGHTS OF SEEDS OF AQUATIC PLANTS IN SAMPLES FROM ILLINOIS RIVER VALLEY, 1941 AND 1942.

Plant and condition of seeds when measured (all air dried)	Grams per cubic centimeter
Longleaf pondweed; nutlets dry and free of other plant parts	0.64
Bur-reed; nutlets dry, free of sepals	0.60
Duck potato; nutlets free of stem and sepals	0.54
Arrowleaf; nutlets free of stem and sepals	0.55
Wild rice; seeds with floral envelopes	0.93
Teal grass; seeds free of plant debris	0.86
Chufa; akenes mixed with little chaff	0.50
Straw-colored nutgrass; akenes mixed with little chaff	0.74
Red-rooted nutgrass; akenes mixed with little chaff	0.74
American bulrush; nutlets without other flower parts	1.00
Pickerelweed; pericarp present but dry	0.39
Japanese millet; seeds with floral envelopes	0.72
Walter's millet; seeds with floral envelopes	0.49
Wild millet; seeds with floral envelopes	0.64
Largeseed smartweed; seeds without floral envelopes	1.00
Nodding smartweed; seeds without floral envelopes	0.99
Marsh smartweed; seeds without floral envelopes	0.82
Dotted smartweed; seeds without floral envelopes	0.60
American lotus; seeds free of plant debris	1.10
Buttonbush; seeds free of plant debris	0.50

during midsummer, 1942, from the glacial lakes region of northeastern Illinois, but are not included in the Illinois River Valley data. A total of 186 samples was collected from three lakes with stabilized water levels, 233 samples from seven lakes with semistabilized water levels and 371 from nine lakes with fluctuating water levels. The number of samples taken for each plant species varied according to its relative abundance and its value as shown from previous food habit studies.

Despite reasonable care, some seed was lost in harvesting and in assaying. It was impossible to gather every seed from a sample area or plant, and from some seeds it was impossible to separate entirely a small amount of chaff. These may have affected the accuracy of the figures slightly, but with many samples and the nature of the work the errors are believed to be insignificant.

SEED YIELDS

The seed heads and the individual plants covered varying amounts of space. Plants with inflorescences at different heights may produce more seeds than those with inflorescences on only one plane. The "layer" arrangement is more pronounced in some plants than others and consequently influences the yield of seed by various species. Thus, pigweeds or nodding smartweeds, produce at several levels and might be expected to produce more than lotus or marsh smartweed, which flower at only one level. Likewise, coontail in 6-foot water has more space for foliage than the same plant in 18 inches of water. Since the prime objective was to determine how much seed or foliage can be produced by certain species on a given area regardless of depth of the water or height of the plants, the depth dimension or effect of layering was not considered in the comparison of yields. All figures are based on the unit of area—one square meter.

The growing season of 1941 was better than average along the Illinois River. Water levels in all classes of lakes remained fairly constant from

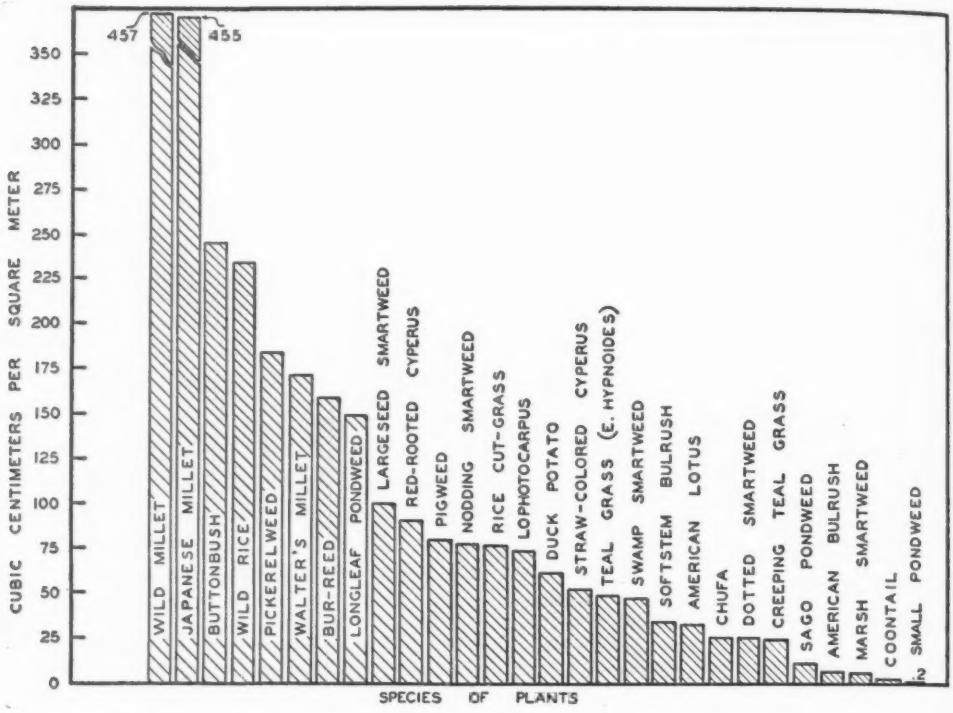

Fig. 1. Yields of seeds by important aquatic plants in lakes of all types, Illinois River Valley, 1941 and 1942.

early July until October 6. Flood waters raised the level of most lakes 6 to 8 feet above normal on October 9 to 11, but most seeds then were mature. The stage of water prevailing during the summer was low enough to permit good growths of moist-soil plants. Submerged plants also had ideal growing conditions. The 1942 season was not so favorable for aquatic plants although good growths were made by submerged species.

The production of seed by aquatic plants varied between species and between samples of the same plant taken under different environmental conditions. This was to be expected since there are many variables. In general, the production of seed by aquatic plants ranked favorably with that of upland plants. The average of all samples collected was 101.2 cc. per square meter of surface occupied by the plants sampled. This was an average of about 14 bushels of seeds per acre. Those with the highest yields averaged slightly above 60 bushels of seeds per acre and the lowest seed producers yielded only a few pounds to an acre. The seed yields of the 28 plants studied are shown in Fig. 1. The salient facts about the yields of these species are discussed below, approximately in descending order of productiveness.

Wild millet (*Echinochloa crusgalli*) was the top seed producer among the 27 waterfowl food plants studied, yielding an average of 457 cc. of seeds per square meter of surface, and was a particularly uniform producer.

Japanese millet (*Echinochloa frumentacea*) produced almost as much as wild millet, 455 cc. per square meter. The two millets widely out-yielded all the other plants studied. They produced 43 per cent more seed than buttonbush. This output goes far toward explaining the high rank of these species, third among duck food plants in the Illinois River Valley, as pointed out by Bellrose and Anderson (1943).

When the water level drops in shallow-basined lakes and exposes mud flats early in summer, wild millet, which is not adversely affected by winter temperatures, germinates from seeds deposited in previous years. In Illinois, Japanese millet must be sowed each year, as winter temperatures destroy the viability of the seeds.

Buttonbush (*Cephalanthus occidentalis*) was third in seed production, with 245 cc. per square meter. According to studies by Bellrose and Anderson (1943) on its occurrence and use by ducks, however, it ranked twelfth in value locally as a duck food. Its low value may be due in part to many of its seeds being inaccessible to ducks, but the seeds are not as palatable or sought after as much as those of most other species. Buttonbush forms a border around many Illinois River Valley lakes and starts to fruit when only 18 to 24 inches high. On shrubs 8 to 10 feet high, seeds are produced on the ends of all branches, from near the ground to the top.

Wild rice (*Zizania aquatica*) was fourth in seed yield, 234 cc. per square meter. The seeds on any one panicle mature and fall at different intervals; the pistillate spikelets were enclosed in a cloth sack before maturity. Samples so collected together with count of the average number of fruiting panicles over a given area yielded the above figure. The 234 cc. of seeds represent the potential production of wild rice locally under ideal conditions. Samples were taken in dense, luxuriant stands of plants 10 to 15 feet tall. Under actual field conditions seed production was materially lessened by the larvae of a moth (probably *Septis*) on the rice grains in the milk stage. Bellrose and Anderson (1943) found that wild rice is not a valuable duck food plant in this locality because the small and scattered patches are invaded by thousands of blackbirds during late August and September which evidently consume most of the seeds produced.

Pickerelweed (*Pontederia cordata*) was fifth in seed production, yet Bellrose and Anderson rated it twentieth in value as a duck food. Since the seeds are readily accessible to ducks in the shallow open water of ponds, we must conclude that their low value is due to unpalatability. In most Illinois lakes, pickerelweed grows in dense but scattered beds and only in areas with stable or semistable water levels. A total of 28 samples averaged 185 cc. of seed per square meter.

Walter's millet (*Echinochloa Walteri*) was considerably below other millets in the yield of seed during 1941. Its growing period is longer than that of the others; because of the high water early in the summer of 1941, it had a shorter growing season than in 1940, when there

was heavy fruiting. Seed production in 1941 undoubtedly was well below that of 1940 when it ranked second in value as a duck food plant. A yield of 306 cc. of seed per square meter at the Chautauqua National Wildlife Refuge probably more adequately portrays its normal production than the over-all yield of 171 cc. of seed per square meter. The higher value of this plant for ducks than either wild or Japanese millets, as indicated by use, may be due to several possibilities: pintails and teals may actually prefer the smaller seeds of Walter's millet; many seeds of Japanese millet shatter and germinate the same season; and blackbirds consume more seeds of wild and Japanese millet than of Walter's millet.

Bur-reed (*Sparganium eurycarpum*) was seventh in seed production and sixth in value as a duck food. The average seed yield was 158 cc. per square meter; on lakes with stabilized water levels it produced 288 cc. per square meter, thus more than buttonbush. There were successively lesser amounts produced in lakes with semistable and fluctuating water levels as not every plant had a fruiting stalk, the average being 25 plants but only 16 fruiting stalks per square meter.

Longleaf pondweed (*Potamogeton americanus*) produced more seed than other floating and submerged aquatic plants. The 48 samples averaged 147 cc. of seed per square meter, nearly 14 times that of an equal area of sago pondweed (*Potamogeton pectinatus*). Bellrose and Anderson found longleaf pondweed to be over five times more valuable as a duck food plant than sago pondweed. The greater value of longleaf pondweed must be attributed to its larger yield of seed; it was eighth in seed production, and eleventh in value as a duck food.

The largeseed (*Polygonum pennsylvanicum*), one of the more widely distributed smartweeds, ranked ninth in seed yield, 100 cc. per square meter. Growing on moist soils in habitats similar to those of nodding smartweed (*P. lapathifolium*), it outproduced the latter by about 22 cc. per square meter. Largeseed smartweed produced about 2¼ times as much as swamp smartweed (*P. hydropiperoides*), and 4 times as much as the dotted smartweed (*P. punctatum*). These smartweeds rank ninth, twelfth, eighteenth and twenty-second, respectively, in yield of seeds, but as a group the four species were placed fourth in value as duck foods, indicating that their seeds are highly palatable and actively sought after by waterfowl.

Nutgrasses (*Cyperus* spp.) and teal grasses (*Eragrostis* spp.) have minute seeds. The red-rooted nutgrass (*C. erythrorhizos*) yielded 91 cc. of seed per square meter, only slightly less than largeseed smartweed. The former produced nearly twice as much seed per area unit as *C. strigosus* and four times that of chufa (*C. esculentus*). The nutgrasses averaged about 7 cc. of seed less per square meter than moist-soil smartweeds, and the latter were only slightly greater in value as duck foods than the nutgrasses.

Water hemp (*Acnida tuberculata*) has small pinhead-sized, dark-colored seeds which aggregated 85 cc. of seed per square meter. Its seed yield is above that of moist-soil smartweeds and the nutgrasses, but its value for ducks is about one-eighth that of the others named.

Rice cut-grass (*Leersia oryzoides*),

first in value as a duck food plant, was thirteenth in seed production. Its rootstocks and shoots add greatly to the amount of food the plant affords. The seed production was 80 cc. per square meter. Moisture conditions greatly affected the yield of seed from this plant.

Arrowleaf (*Lophotocarpus calycinus*) and duck potato (*Sagittaria latifolia*) ranked fourteenth and fifteenth, respectively, in seed yield, the former yielding 73 cc. and the latter 62 cc. per square meter. However, duck potato in lakes with stable water levels produced slightly more seed than arrowleaf in lakes with fluctuating levels. Martin and Uhler (1939) suggest that the seeds of *Lophotocarpus* may be more readily available than those of *Sagittaria* because seed heads of the former appear to persist intact longer. *Lophotocarpus* may also be of greater value than *Sagittaria* through the production of more seed. Duck potato ranked ninth in value as a duck food, and, since few of its large, deeply buried tubers were consumed, the indications are that its seeds may be better relished and more readily accessible to ducks than commonly believed.

Duck potato averaged 16 fruiting stems per square meter, with 30 seed heads per stem, and arrowleaf 63 fruiting stems with 8 seed heads per stem. Beds of duck potato averaged 25 plants to a square meter, and those of arrowleaf 16 plants.

Teal or love grasses (*Eragrostis* spp.) are small, procumbent plants that form dense patches, often as an understory of larger moist-soil plants. *E. hypnoides*, by far the most abundant of the genus, yielded 46 cc. of seed per square meter, but *E. pectinacea* only 18 cc.; the latter square grew on sandy soil, whereas *hypnoides* occurred on alluvial loam deposits.

Bulrushes (*Scirpus* spp.), because of their seed production, are valuable duck food plants in many sections of North America. They have only a low seed yield in the Illinois River Valley. Softstem bulrush (*S. validus*) produced more than any other bulrush, 34 cc. per square meter, whereas American bulrush (*S. americanus*) was low in seed production, only 7 cc. of seed per square meter. The scant and poor growth of the latter on the sandy shores of a few local lakes well may indicate that environmental conditions in the region are far from optimum. In the glacial lakes region of northeastern Illinois where the luxuriant beds denote an optimum environment the yield was 24 cc. of seed per square meter. A few samples from hardstem bulrush (*S. acutus*) indicated a yield of 22 cc. of seed per square meter. River bulrush (*S. fluviatilis*) is the most abundant aquatic plant in the Illinois River Valley, but seldom fruits there. Thousands of acres were inspected during the past four years and this species was found fruiting on only three small areas. It is no wonder then that the species comprised only 0.50 per cent of the food taken by ducks in the valley.

American lotus (*Nelumbo lutea*) produces extremely hard, spherical, nutlike seeds about 10 mm. in diameter, about 20 in each light, spongy, top-shaped receptacle. The heads appeared to be numerous, but averaged only 2.1 with a yield of 33 cc. of seed per square meter. A plant with this amount of seed, and comprising over 23 per cent of the aquatic vegetation in the valley, might be expected to be an important duck food; lotus seeds, however, formed only

0.35 per cent of the diet of 3,200 ducks examined by Bellrose and Anderson. Wood ducks feed extensively on the seeds before they harden late in summer; their slight use by most waterfowl is probably because of their hardness.

Marsh smartweed (*Polygonum Muhlenbergii*) is a valuable and abundant duck food, forming 6.6 per cent of the diet and 7 of the aquatic vegetation (Bellrose & Anderson 1943); but produces few seeds. In view of the low yield, its large consumption by waterfowl is particularly noteworthy. Beds of marsh smartweed are especially attractive to waterfowl because they offer ideal cover. Their intensive use for loafing and roosting, combined with the highly palatable and nutritious seeds which are readily accessible in water less than 20 inches deep, may account for the many seeds in the diet. The 87 samples from such beds averaged 6 cc. of seeds per square meter.

Sago pondweed (*Potamogeton pectinatus*) yielded only 10.6 cc. of seed to a square meter; it was twenty-fourth in place, far below that of longleaf pondweed. Many beds of sago pondweed were in unfavorable habitats where seed yield was erratic, and numerous beds produced no seed. This accounts in part for its poor showing as a duck food in Illinois River Valley lakes. After the ripening of seeds in many beds, the vegetative parts disintegrate and sink, rendering the leaves and stems unavailable to waterfowl in the autumn. Only small amounts of foliage and tubers have been found in the thousands of duck gizzards analyzed. This species is one of the most valuable duck food plants in many sections of the United States, but ranks sixteenth in the Illinois River Valley.

Small pondweed (*Potamogeton pusillus*) has small seeds and spikes and produced only 0.2 cc. of seed to a square meter. Bushy pondweed (*Najas guadalupensis*) fruited heavily, but, because of difficulty of separating the minute seeds from the foliage, no quantitative analyses were made. Seeds of these pondweeds if taken by ducks would probably be ingested along with vegetative parts of the plants. Small pondweed disappeared after fruiting in midsummer and was replaced by coontail (*Ceratophyllum demersum*) and bushy pondweed. The latter plants formed only traces in the diets of Illinois River Valley ducks, despite appreciable quantities of them in several lakes.

Coontail averaged only 1.5 cc. of seed per square meter, but under favorable conditions of stable and clear water yielded 9 cc. per square meter. Seeds were found only on plants in lakes with stable or semistable water levels and only a few seeds were produced in the latter. While coontail produced little seed, it ranks seventh as a duck food plant. Its value in Illinois lies in the leaves and stems, which are consumed avidly.

VEGETATIVE PRODUCTIVITY

To determine the various environmental conditions under which submerged plants produced the greatest amount of foliage, 325 samples of these were collected and weighed. Each species was collected from pure stands and also where competing with a mixture of aquatics. Samples were taken from lakes with various types of water levels. Rickett (1921) in Wisconsin collected from area units and then separated the samples into component species. He found the average dry weight of the aquatic

plants to be 202 grams per square meter. Since he did not collect from beds where each species grew separately, the weights for species in his work and the present study are not entirely comparable. Rickett reported the dry plant foliage per acre for various depths of water as follows: up to 1 meter deep, 1,600 pounds; 1 to 3 meters deep, 2,400 pounds; and more than 3 meters deep, 1,300 pounds. His grand average for 21 species was 1,801 pounds per acre.

TABLE 2.—WEIGHTS OF FOLIAGE IN PURE GROWTHS OF SUBMERGED AQUATIC PLANTS IN LAKES, ILLINOIS RIVER VALLEY, 1941 AND 1942 (AIR DRIED, GRAMS PER SQUARE METER).

Plants	Lake water level		
	Stabilized	Semi-Stabilized	Fluctuating
Coontail	325	264	—
Sago Pondweed	222	—	392
Longleaf Pondweed	144	158	—
Bushy Pondweed	108	—	95
Leafy Pondweed	57	—	—
Duckweeds	33	31	—

Five of the most important and abundant waterfowl food plants sampled by us (Table 2) averaged 127 grams of foliage per square meter, or 975 pounds per acre. Coontail was first with 325 grams per square meter (2,508 pounds per acre) and sago pondweed second with 222 grams (1,707 pounds per acre). Then in order were longleaf pondweed, 144 grams; bushy and leafy pondweeds, 108 and 57 grams, respectively. Duckweeds under optimum growths in protected areas yielded 33 grams per square meter (about 244 pounds per acre). Plants included in the samples of duckweeds were *Lemna minor*, *Spirodela polyorhiza* and *Wolfia* spp.; the density varied greatly where they were exposed to changing winds or to waves.

The fact that Rickett (1921; 1924) recorded 1,801 pounds per acre in Lake Mendota and 1,590 pounds of similar plants in Green Lake, while our average was only 975 pounds per acre, reflects apparent differences in environmental conditions and some attributable to growth of certain different species. The clear, stable waters of Wisconsin glacial lakes would seem to be more suitable for growth of submerged aquatics than the fairly turbid, unstable lakes of the Illinois River valley.

INFLUENCE OF ENVIRONMENT ON YIELDS

The effect of adverse environmental conditions on the development of waterfowl food beds has been discussed by McAtee (1939), Martin and Uhler (1939) and Bellrose (1941). Martin and Uhler state that "no single factor is more potent in preventing the development of waterfowl feeding grounds then extreme or irregular fluctuations in the water level." Bellrose reported on the direct and indirect influences of excessive fluctuations on the aquatic growths in lakes bordering the Illinois River. Under such conditions both vegetative growth and production of seed are checked. In 1942, sudden and extreme rises in the water levels inundated and killed innumerable beds of submerged aquatics such as sago pondweed and so retarded the growth of duck potato and millet that seed was not produced in many beds.

The seasonal fluctuations during 1941 were not abnormally severe, but the seed production of seven important

species thriving in the three classes of lakes varied. Seed yields of longleaf pondweed (grams per square meter) were as follows: stable water levels, 184; semistable water levels, 148; fluctuating water levels, 58. Variations in seed yields of sago pondweed varied similarly. Coontail yielded 9 cc. in stabilized lake levels, but only a trace in semistable lakes.

Water fluctuations change the amount of sunlight reaching the plants, and also produce variations in transparency of the water because of silt. Such changes may affect submerged aquatics profoundly not only at the time of seed production but throughout the growing season. Except for extreme floods which cover mature plants, most of the effect of higher water on emergent plants is during the early growing season when they are small. Fluctuations then either delay growth or eliminate many plants, and both conditions may affect the amount of seed produced. Three important emergent plants were sampled from the three classes of lakes; in each instance seed yield was considerably higher in stable lakes than in semistable ones. Bur-reed yielded 2.7 times as much seed per unit area in stable lakes as in those with semistable levels and over 6 times as much as in lakes with fluctuating water levels.

Emergent moist-soil plants yielded more seed than any other types of

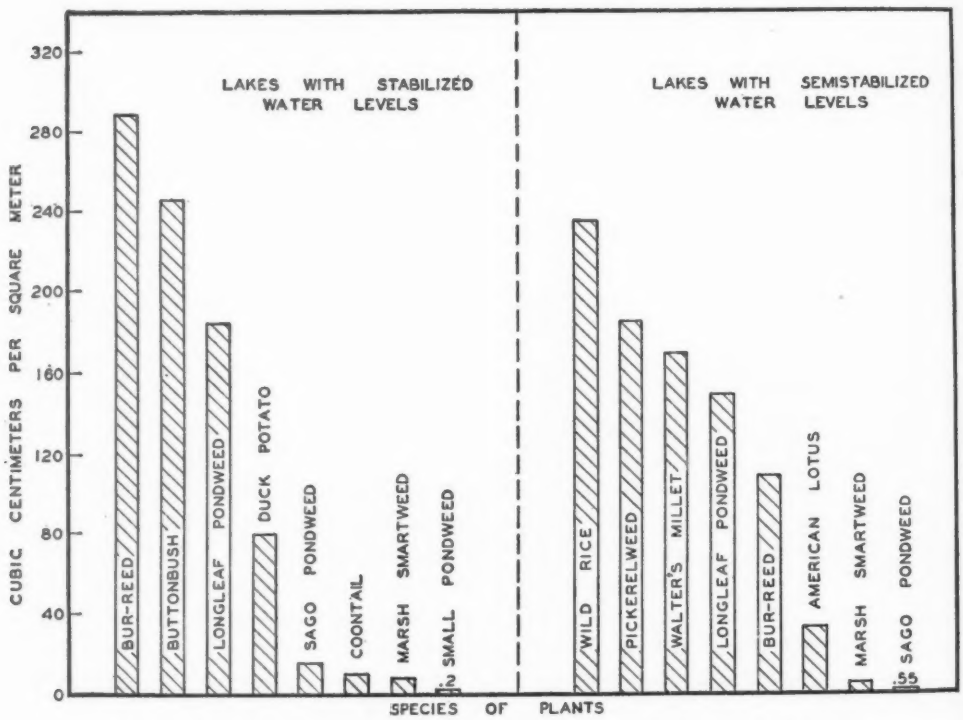

Fig. 2. Yields of seeds by aquatic plants in lakes with stabilized and semistabilized water levels, Illinois River Valley, 1941 and 1942.

plants in the three classes of lakes. The best producers in lakes stable with water levels were bur-reed, buttonbush and longleaf pondweed in the order listed; in semistable lakes they were wild rice, pickerelweed, Walter's millet, and longleaf pondweed; and in those with fluctuating levels were the millets —wild, Japanese and Walter's (Fig. 2,3).

Water depths within the growth range of the species, the transparency of the water, soil conditions and degree of competition between plants of the same and other species are the factors importantly influencing the yield of the seed of aquatic plants.

WATER DEPTH

For each species a water depth optimum for maximum seed production was found. When greater or less than the optimum, the yields varied markedly. Longleaf pondweed yielded about 175 cc. at 16 to 20 inches of water and up to 450 cc. of seeds at 24 inches, but only 25 to 50 cc. in 8 to 10 inches. Bur-reed showed greatest seed yields in 6 to 12 inches, and decreased with shallower or deeper water. Duck potato showed a steady increase in yield with an increase in water depth up to 18 inches. Fruiting of the marsh smartweed appeared to be directly correlated with water depth, increasing to about 20 inches and then decreasing. In many smartweed beds which were dry or nearly dry during the summer months, the plants fruited very sparingly or not at all. Fruiting spikes on plants in shallow water matured few seeds. Flowering of the marsh smartweed progressed from deeper water to shallower water as the season advanced.

Rice cut-grass normally grows on the rich black soil of bars and water margins where, characteristically, the levels fluctuate. Its yield generally was correlated with water depth, the largest, of 158 cc., on areas with 6 inches of water. The yield in soil with a water table 6 to 15 inches below the surface was approximately one-third of the preceding. The amount of moisture during the growing season determined largely the type of inflorescence present. In general, there were more panicles growing free of the sheaths on plants in water, and the sheathed forms of inflorescence was more abundant in drier sites. For full utilization of seeds and rootstocks and maximum production of seeds, the ground surface should be covered by an inch or two of water during the growing season and autumn.

WATER TRANSPARENCY

Excessively turbid waters have an adverse effect on growth of both submerged aquatics and emergent species during the early growing season. When the latter are above water, however, increased turbidity has little effect.

A transparency of less than about 9 inches was found to retard development. Seed production in many submerged aquatics appeared to be lowered by turbidity. Turbidity lowers the energy of plants by inhibiting photosynthesis, thus eventually lowering seed yields. Sago pondweed samples from lakes with stabilized water levels showed the greatest seed production where the water was fully transparent. At the Chautauqua National Wildlife Refuge with water depth and transparency of 28 inches, the seed yield of sago pondweed was 37 cc. per square meter, while at a different station in the same lake showing 18 inches of transparency

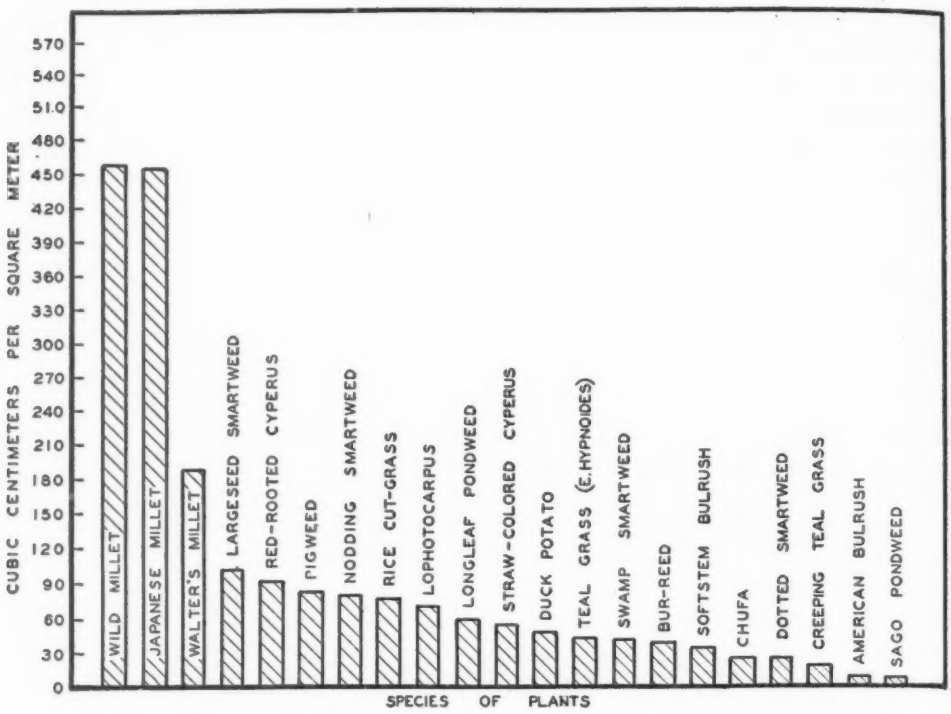

Fig. 3. Yields of seeds by aquatic plants in lakes with fluctuating water levels, Illinois River Valley, 1941 and 1942.

in 44 inches of water the yield was only 7 cc. Sago pondweed at Muscooten Bay produced 15 cc. of seed in water having a transparency of 9.5 inches and 26 cc. in Peoria Lake in water having a transparency of 15 inches.

SOILS

Soils from which the plants were sampled for seed yield were recorded as to degree of compactness and general texture. The composition of soils in which submerged aquatic plants grew varied more in compactness than those on which moist-soil and emergent plants were found. Thus, the soil on which sago and longleaf pondweeds thrived varied from hard clay loam to soft black silt, while most emergent and moist-soil plants thrived on hard silty loams or on sand loam flats. The heaviest yields of pondweeds, both vegetative parts and seeds, were on soft silt loams. Duck potato on soft black silt at Clear Lake averaged 70 cc. of seed, whereas the same plant on hard-packed clay yielded only 15 cc. Longleaf pondweed under similar water conditions in Beebe Lake produced 571 cc. of seed in soft silt loam and 264 cc. in hard silt loam.

Of the aquatic plants sampled for seed, 22 were growing in black silt loam, 4 in clay loam, and 5 in sand or sandy loam. Those thriving well in sandy situations and producing good crops of seeds were chufa (*Cyperus esculentus*), teal grass (*Eragrostis pec-*

tinacea), certain smartweeds, particularly the largeseed, and the American bulrush. Plants that thrived in hard clay loams were largeseed smartweed, bur-reed, straw-colored nutgrass, and wild millet. Other plants appeared to thrive in clay or sandy soils but attained their best development in black silty loams where fertility is undoubtedly greatest. Lake bottoms which were exceedingly oozy did not support good growths of aquatics.

PLANT COMPETITION

Martin and Uhler (1939) have emphasized the importance of plant competition in the development of aquatic plants. They point out the need of additional information on the effect one species may have on development of another and the effects of undesirable species on more desirable plants. Our data, on the effect of competition on seed and foliage yields, pertain chiefly to coontail and to the influence which different plant species exert. Pure growths of coontail yielded the highest weight of dried plants per square meter (Table 3). Successively denser stands of American lotus reduced the yield, and with a complete canopy of lotus only one-fourth the yield was obtained as that where lotus covered less than 10 per cent of the water surface. Coontail

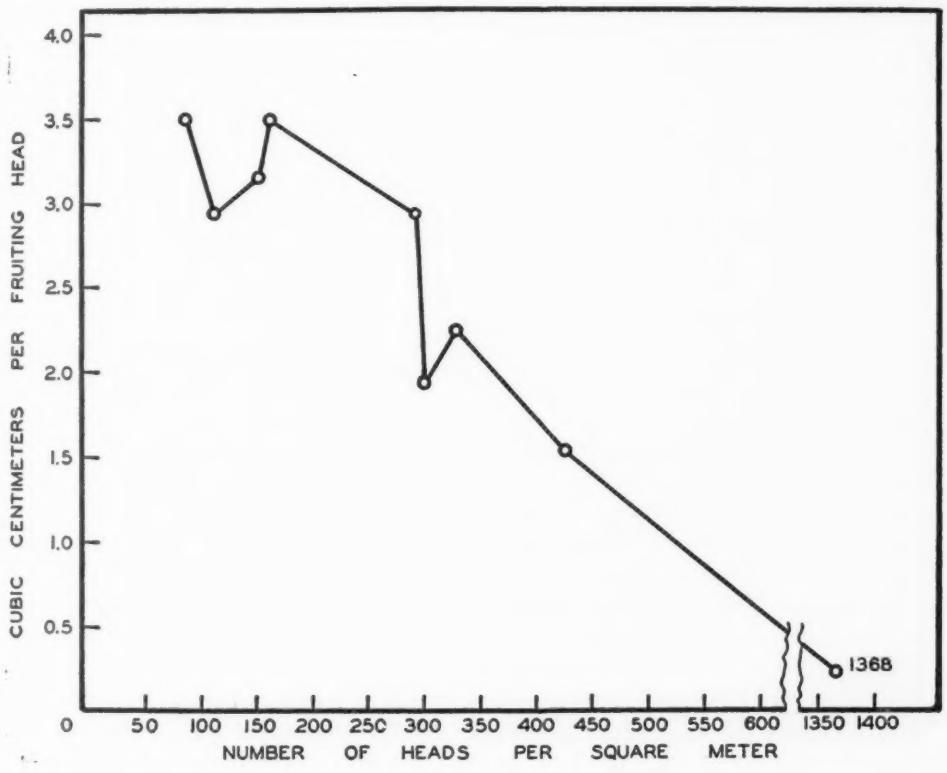

Fig. 4. Yields of seeds by Japanese millet (*Echinochloa frumentacea*) sampled in areas of different plant densities, Illinois River Valley, 1941 and 1942.

under a partial blanket of duckweeds averaged 168 grams of foliage but under a dense blanket of duckweeds only 18 grams per square meter. Light yields of coontail were taken from sparse stands of river bulrush and from areas covered with white water lilies.

TABLE 3.—EFFECT OF PLANT COMPETITION ON THE GROWTH OF COONTAIL, ILLINOIS RIVER VALLEY, 1941–1942, AS SHOWN BY PRODUCTION OF COONTAIL UNDER VARYING DEGREES OF PLANT COMPETITION.

Kind and degree of competition	Coontail, air-dried (grams)
Coontail, pure growth, lakes with stabilized water levels	325.0
Water weeds, thin growths	123.0
River bulrush, medium stands, 138 stalks per square meter	55.4
White water lilies, 60 per cent of water surface covered	130.0
Duckweeds, partial blanket	168.0
Duckweeds, dense blanket	18.0
American lotus, 1 to 10 per cent of water surface covered	86.0
American lotus, 33 per cent of water surface covered	73.0
American lotus, 75 per cent of water surface covered	69.0
American lotus, water surface completely covered	22.0

In the Illinois River Valley, Japanese millet is often planted beneath American lotus, which is cut after the millet has started growing. The lotus shades the ground and keeps it moist until the millet seed germinates. In lakes where the lotus acts as a nurse crop, fair yields of millet are obtained. Millet grown under these conditions, however, is spindly and has small seed heads as compared with plants grown under optimum conditions; late plantings also may affect the yield. Yields from late plantings average less than 50 per cent of normal yields.

Competition resulting from plantings that are too dense and from natural growths of aquatic plants often lowers the yield of seeds, particularly in millets. The total yield of seed was progressively lower with an increase in plants per unit area and the size of the individual heads was smaller with overcrowding (Fig. 4). Maximum yields of

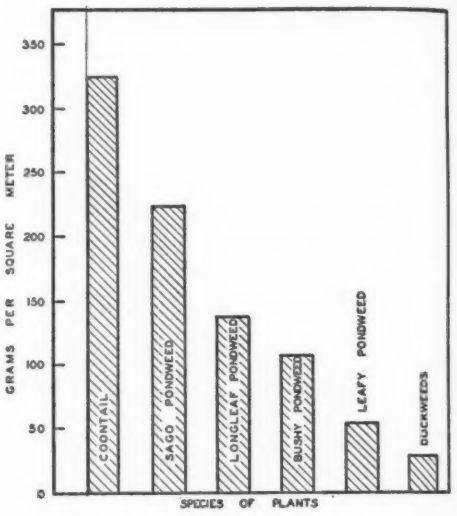

Fig. 5. Dry weights of aquatic plants in lakes with stabilized water levels, Illinois River Valley, 1941 and 1942.

Japanese millet were produced with an average of 250 to 350 plants per square meter; 50 per unit area yielded approximately 300 cc. of seeds and stands of 500 or more about 550 cc. per square meter. The volume of seeds per head was greatest when the plants averaged 100 to 150 plants per square meter. Under good growing conditions, sowing millet thinner than is ordinarily practiced will produce more food and also reduce planting costs.

The best seed yields from pigweed (*Acnida tuberosa*) were with plants 18 to 36 inches high and numbering 200

to 400 per square meter. In less dense stands the plants often grew 6 to 9 feet in height and were many-branched, but they did not yield as much seed per unit area as smaller and more uniform plants. When too dense (above 500 per square meter), they did not produce maximum yields. Large and many-branched plants of nodding smartweed (*Polygonum lapathifolium*) 72 inches high produced less seed per unit area than small uniform stands 36 to 48 inches high.

SUMMARY

1. The seed productivity of 28 waterfowl food plants in the Illinois River Valley was measured by 790 samples and the foliage production of 6 submerged species also was determined.

2. The samples were taken from 19 lakes, 3 with characteristically stable water levels, 7 with semistable water levels and 9 with fluctuating water levels.

3. The average seed yield was 101.2 cc. per square meter of plants, or about 14 bushels of seed per acre. Foliage production averaged 127 grams dry weight per square meter, or about 975 pounds an acre.

4. Of the seven heaviest seed producers, six were emergent or moist-soil plants and one, a submerged species, the longleaf pondweed (*Potamogeton americanus*). Millets (*Echinochloa crus-galli* and *E. frumentacea*) were the highest seed producers with 457 and 455 cc. per square meter. Other plants high in yield were buttonbush (*Cephalanthus occidentalis*), pickerelweed (*Pontederia cordata*), and Walter's millet (*Echinochloa Walteri*).

5. Weight of air-dried foliage samples of submerged aquatics collected under optimum growing conditions showed coontail (*Ceratophyllum demersum*) to be the heaviest producer and longleaf pondweed and sago pondweed (*Potamogeton pectinatus*) next in order.

6. Environmental and edaphic factors affected the normal yields of seeds and foliage. Foremost among these were water depth, water transparency, and soil type. Such plants as longleaf pondweed, duck potato (*Sagittaria latifolia*), bur-reed (*Sparganium eurycarpum*), and marsh smartweed (*Polygonum Muhlenbergii*), thriving in different water depths of several lakes, varied considerably in yield of seeds. Turbidity resulting from suspended silt in the water decreased seed yields of sago pondweed and retarded development of other submerged plants. Certain plants typically grew on sandy soils but a majority of the aquatics attained optimum seed productivity in lakes on black silt loams.

7. Plant competition affected the amount of seeds produced. In general, uniform and medium stands produced the highest yields of seed and should be encouraged in planting programs or in management practices where plant densities can be controlled. The potentially high yield of wild rice (*Zizania aquatica*), and probably that of other species, is lowered materially by worms which consume the seeds.

LITERATURE CITED

BELLROSE, FRANK C., Jr. 1941. Duck food plants of the Illinois River Valley. Ill. Nat. Hist. Surv. Bul., 21: 237–270.

BELLROSE, FRANK C., Jr., and HARRY G. ANDERSON. 1943. Preferential rating of duck food plants. Ill. Nat. Hist. Surv. Bul., 22: 417–433.

MARTIN, A. C., and F. M. UHLER. 1939. Food of game ducks in the United States and Canada. U. S. Dept. Agric. Tech. Bul., 634. 156 pp., illus.

McATEE, W. L. 1918. Food habits of the mallard ducks of the United States. U. S. Dept. Agric. Bul., 720. 36 pp., illus.

1939. Wildfowl food plants. Ames, Iowa, Collegiate Press, Inc. 141 pp., illus.

PIRNIE, MILES DAVID. 1935. Michigan waterfowl management. Lansing, Mich., Michigan Department of Conservation, 328 pp., illus.

RICKETT, H. W. 1921. A quantitative study of the larger aquatic plants of Lake Mendota. Wis. Acad. Sci. Arts and Let., Trans., 20: 501–527.

1924. A quantitative study of the flora of Green Lake, Wisconsin. Wis. Acad. Sci. Arts and Let. Trans., 21: 381–414.

SURVIVAL OF HATCHERY-REARED BROWN AND RAINBOW TROUT AS AFFECTED BY WILD TROUT POPULATIONS[1]

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This paper presents information on the survival of hatchery-reared trout obtained from experimental plantings made at the Convict Creek Experimental Station over the last five years. Fisheries investigators have developed two methods for evaluating the results of stocking fish. These are the creel census and the sampling of total populations in selected areas of stream at the end of specified periods of time. The former produces data on the end result in terms of legal fish landed but fails to give adequate information on sub-legal trout or any information relative to the effect of competition or predation by populations of resident fish, naturally propagated. The second method was used in the studies reported here. Only data on survival of hatchery trout in relation to wild populations will be given. Subsequent papers will treat of growth, condition, and other problems.

The Convict Creek Station is located 40 miles north of Bishop, California, at an elevation of 7,200 feet. The stream is typical of those draining from the eastern escarpment of the Sierra Nevada, having its origin in the permanent snows of the Sierran crest at 12,000 to 13,000 feet. It falls rapidly in its 12-mile course to 6,800 feet where it empties into Lake Crowley, an artificial reservoir on Owens River. The flow is fairly even from season to season. Precipitation varies from 10 inches at Lake Crowley to over 20 inches in the glaciated basin near the mountain crest. The winters are cold and accompanied by high winds and deep snows, particularly at the middle and upper elevations.

In the vicinity of the Station, Con-

[1] Dr. Frank Weymouth gave much advice on the analyses of data presented here. J. W. Moffett, O. R. Smith, H. J. Rayner, Reed S. Nielson, F. H. Sumner, F. K. Cramer, and W. Douglas Mottley aided in the collection of field data. Thanks are also due the Rainbow Club of Bishop, California, the U. S. Forest Service, and the California State Division of Fish and Game; the last agency furnished all fish for planting.

vict Creek averages about 12 feet in width where it traverses meadow and upland livestock range. It is a good, typical cold water trout stream with fair cover and food, and under normal conditions is subjected to intensive angling in the summer. Originally it was barren of trout, but the cutthroat (*Salmo henshawi*), brown (*S. trutta*), golden (*S. agua-bonita*), rainbow (*S. gairdnerii*), and eastern brook trout (*Salvelinus fontinalis*) all have been introduced. Brown trout predominate in catches by anglers.

EXPERIMENTAL STREAM SECTIONS

Five side channels with a total length of 4,200 feet were developed from old meanders of Convict Creek in 1937 and designated A, B, C, D, and E. Each in turn was divided into 100- to 400-foot sections by dams keyed for wire cloth screens on wooden frames which serve to prevent fish from entering or leaving any given section. Flashboards fit into the flumes below the screens to regulate water levels and to help in keeping the screens free of debris (Needham and Rayner, 1939). In the experiments reported here, most sections of A, B, C, and E were used. These total roughly 3,482 linear feet, or approximately 0.56 surface acre of stream. They range in width from 5 to 11 feet. Shelter is provided by logs, roots, pools, undercut banks, and willows growing at the water margin. During periods of operation, a flow of approximately 2 cubic feet per second is diverted from the main stream into the channels, and conditions are maintained as nearly natural as is possible except for the division into individual sections. In essence, the channels may be considered as "controlled," small nursery-type trout waters. The area was fenced and posted to exclude anglers and livestock.

METHOD OF OPERATION

The screens were installed and experiments begun each season as early in the spring as physical conditions permitted, or as soon as the fish needed could be obtained from hatcheries. The screens separating the experimental sections were installed and made fish-tight before any fish were planted. Screens were usually cleaned at least five times a day and thus were inspected adequately at all times.

The hatchery fish planted in the various experiments were marked by clipping off one or more fins to distinguish them from the wild trout normally present. Wild trout were not removed prior to planting. All samples of planted fish were weighed and measured when fresh. Similarly, at the end of each operating season, all weights and lengths were taken fresh to avoid errors due to preservation in formaldehyde. Needham and Rayner (1939) have reported in detail on the techniques employed.

Most of the wild fish were brown trout, less than one per cent being rainbow. The brown trout migrate into the experimental sections in late October and November to spawn. Few of these wild fish are the immediate result of hatchery plantings. Under an agreement with officials of the California Division of Fish and Game, no trout were planted in Convict Creek within a mile of the Station. Since 1938, only rainbow trout have been planted in Convict Lake, about two miles upstream from the Station. Needham and

Cramer (1943) reported few rainbow as migrating out of Convict Lake, and since the bulk of the wild fish in the sections are brown trout, obviously they were not of that origin. All trout, wild as well as planted, were removed each season at the conclusion of the experiments. They were weighed and measured individually and were not returned to the stream. Consequently those present in any one season resulted from migration into, or natural reproduction in, the sections during non-operating periods. Fish in the main stream would have to migrate a maximum distance of only 1,150 feet to repopulate all sections. Removals were begun in 1937; hence, from 1938 through 1942, comparable conditions existed from year to year. Since the populations of wild trout were altered by annual removals, the concentrations of them must be considered minimal. The results of the experiments would be comparable to returns following the usual procedures in planting hatchery fish in heavily fished waters. During the period covered, 7,068 wild trout were removed from stream sections in which survival was tested.

STOCKING POLICY

From 1938 to 1942, inclusive, various modifications of the stocking policy recommended by Davis (1938) were used. The numbers recommended in his planting table (p. 21) were changed as seemed necessary to establish separate stocking policies for each experimental section. The factors bearing on the numbers of fish to be planted were those usually analyzed in stream survey work: width, food,[2] length of section, and riffle and pool values. On the basis of Davis' standards, the experimental sections were all classified as "B-3" streams. Since one of the purposes of these investigations was to obtain data fundamental to the development of sound stocking policies, much latitude was used in either reducing or increasing the numbers of fish listed.

METHODS OF ANALYSIS

As a working hypothesis for the analysis of survival data, competition and predation between wild fish and planted fish were assumed to be determining factors. Since 7,068 wild trout were taken from sections in which survival was tested, it was necessary to find a suitable means for evaluating the effect of these resident fish on the survival of those planted. Obviously, since competition and predation from all sizes of wild trout were involved, the number of wild fish would not adequately indicate the total effect. The weight of these wild fish, however, is an adequate measure, according to the findings of physiologists relative to basal metabolism. The two-thirds power of the body weight ($W^{\frac{2}{3}}$) is widely used as a rough estimate in calculating food requirements of farm animals to maintain (but not to increase) body weight. The most recent literature on the subject has shown the metabolism of mammals to be proportional to about the 0.74 power of the body weight (Weymouth, Field and Kleiber, 1942; Weymouth, *et al.*, in press). Studies on the metabolism of

[2] Fifty bottom foods samples, each of one square foot, were taken each year from 1938 to 1942 together with about 100 trout for stomach analyses. These data will be reported separately.

fishes are few, but Morgulis (1915) investigated the gaseous metabolism of a species of flounder in relation to its body weight, from which Weymouth (unpublished) has calculated the metabolism as being proportional to the 0.9 power of the body weight.

The percentage survival of small brown trout fingerlings correlates well with a "food requirement ratio" based on the 0.9 power of the weight. Since there was but a slight difference in the correlations[3] (r values), the actual weight (first power) was used as a basis for the "food requirement ratios" applied in subsequent analysis. The ratio based on actual weights is as follows:

Per cent food ratio = 100(SWp/SWt)

where SWp is the total weight of all planted fish removed from the experimental sections and SWt is the total weight of all fish removed, both wild and planted.

All weights were taken at the end of the operating season, therefore are not truly representative of conditions obtaining throughout the course of the experiments. The ideal ratio would be a mean ratio for the season; however, in Section A during 1942, live weights were taken once a month through the season, and the food requirement ratio was fairly constant, varying from 34 to 45 per cent from month to month. It is believed that the calculated ratio is nearly as representative as any to be obtained except the true mean.

[3] Correlation of per cent survival, using four different powers of the weight, produced the following r values:

Power of weight	r
0.667	0.7722
0.800	0.7864
0.900	0.7977
1.000	0.7843

When the survivals (percentages) were plotted against the percentage food requirement, a curvilinear relationship was evident, so that analysis of correlation was made using the logarithm of the food requirement ratio. The food requirement ratio of the planted trout (a percentage) will hereinafter be termed simply the "food ratio." Correlation analysis was made using the formulae of Treloar (1939) and Fisher (1932). The significance of differences between observed correlations was tested by means of Fisher's z (*op. cit.*).

STOCKING LARGE FINGERLING RAINBOW TROUT

Of this group, 28 experimental lots were planted; 13 were of 35 fish each, three of 9, three of 44, three of 88, four of 101, one of 103, and one of 168. The mean lengths of the trout, when planted, were 2.88 to 3.72 inches total length, the variation being between years. Similarly, the mean weight varied from 4.93 to 11.23 grams. The variation in rate of planting per square foot of water surface area was considerable, 0.015 to 0.123 trout, as was the variation in length of the experimental period (Table 1). The gross survival of all fish of this group was 46.6 per cent and the mean survival per planting was 49.8 per cent.

The simple correlation of percentage survival on the food ratio for this group of plantings had a coefficient, r, of 0.66 (Fig. 1). As is apparent from the figure, this regression must be interpreted with caution. The distribution of points about the line is not normal, and the coefficient of correlation is greatly enhanced by the three points that fall

TABLE 1.—SUMMARY OF EXPERIMENTS WITH LARGE FINGERLING RAINBOW TROUT

Expt. no.	Year	Survival (per cent)	Trout removed (grams)		Food ratio	Trout planted per square foot of water	Operation period (days)
			Planted	Wild			
1	1938	*55.6*	125.1	1,407.1	8.2	0.015	89
2	1938	*75.0*	389.9	1,090.9	26.3	0.059	89
3	1938	*61.4*	707.8	1,664.7	29.8	0.087	89
4	1938	*65.7*	442.8	2,270.3	16.3	0.016	97
5	1938	*30.7*	509.4	2,601.3	16.4	0.121	97
6	1939	*77.8*	87.1	808.8	9.7	0.015	125
7	1939	*97.7*	678.7	289.4	70.1	0.059	125
8	1939	*84.1*	919.3	598.8	60.6	0.087	125
9	1939	*40.0*	358.5	1,424.7	20.1	0.016	128
10	1939	*35.6*	763.0	654.3	55.1	0.121	132
11	1939	*25.7*	219.9	2,965.7	6.9	0.017	128
12	1940	*11.1*	11.1	1,245.1	0.9	0.015	140
13	1940	*22.7*	117.8	915.7	11.4	0.059	140
14	1940	*11.4*	90.1	1,084.8	7.7	0.087	140
15	1940	*68.6*	390.3	2,811.0	12.2	0.016	143
16	1940	*11.9*	147.6	1,430.5	9.4	0.121	144
17	1940	*68.6*	289.7	3,111.9	8.5	0.017	141
18	1941	*94.3*	611.0	1,744.2	25.9	0.016	124
19	1941	*88.5*	594.0	1,761.2	25.2	0.016	124
20	1941	*16.5*	416.3	1,075.0	27.9	0.123	136
21	1941	*8.6*	82.8	3,867.3	2.1	0.017	124
22	1941	*2.9*	14.7	3,935.4	0.4	0.017	124
23	1942	*56.0*	1,127.0	1,460.2	43.6	0.070	151
24	1942	*62.9*	355.8	1,228.1	22.5	0.016	121
25	1942	*82.9*	604.4	979.5	38.2	0.016	121
26	1942	*55.4*	734.5	1,115.8	39.7	0.121	135
27	1942	*40.0*	176.3	2,779.2	6.0	0.017	109
28	1942	*42.9*	223.7	2,731.8	7.6	0.017	109
Means		*49.8*			21.6	0.049	123

near the lower end. Other factors in addition to food competition must be considered as determining the survivals of these plantings. Partial correlation eliminating the variation in the size at planting had no effect in the small fingerling brown trout, and was not attempted with those plantings. Apparently the range of sizes was not great enough to illustrate the effect of this factor. However, the partial correlation eliminating the variance of the concentration at planting (rate of planting) markedly increased the coefficient to 0.85. This is in line with White (1930) who found greater losses among fry when the "fry concentration" was greater. Thus, with a low concentration of fry, survival is greater than with a high concentration even though the food ratio may remain the same. The coefficient of 0.85 means that 72 per cent of the variation in the percentage survival is now explained by its dependence on the food ratio, whereas the simple correlation explained but 43 per cent of this variance. The remaining 28 per cent of the variation is still unexplained. The difference in the lengths of the experimental periods does not account for any demonstrable part of the residual variance. When the effect of the variation in length of experiment as well as the variation in planting rate are both eliminated, the coefficient is still 0.85.

Once the period of initial mortality is over and the trout have become

acclimated, losses apparently are comparatively low for the remainder of the season, and cannot, therefore, be expected to correlate with the food ratio unless food again becomes a limiting factor. One major cause of high initial mortality is probably the sudden change in metabolic level from high to much lower when the fish become entirely dependent on natural food after a rich hatchery diet. Predation then probably is greater while they are becoming adjusted to different environmental conditions.

Survival will not continue to be a measure of the success of the planting. Eventually success will be measured almost entirely by growth, and survival will be relatively independent of food competition under ordinary conditions. In other words, larger fish would be expected to lose weight or at least fail to grow under conditions of heavy food competition, but would not be expected to succumb unless the competition were extremely severe. Consequently the relations expressed in Figures 1 and 2 should not be extended beyond the period of high initial mortality.

SMALL FINGERLING BROWN TROUT

Twenty-one plantings of 50 to 484 fish each furnish the data on survival for this group. Two plantings were of 50 each, two of 100, twelve of 218 to 261, and five of 484 each. The average size varied somewhat from year to year, ranging from 1.25 to 1.56 inches in total length and 0.228 to 0.582 grams in average weight. The plantings were made over a fairly wide range of concentration from 0.033 to 0.180 trout per square foot. The several plantings were under experiment for different periods of time (Table 2). As demonstrated by partial correlation for the large fingerling rainbows above, all experiments encompass the period of high initial mortality following planting. The gross survival for all fish of these plantings was 63.7 per cent; the mean survival per planting was 64.1 per cent.

The coefficient of correlation between percentage survival and food ratio based on the straight weight basis gave

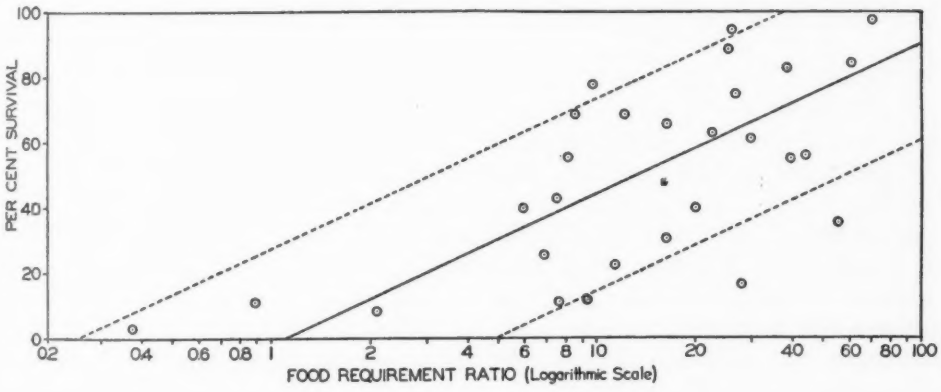

Fig. 1. Relation of percentage survival to food requirement ratio for 28 plantings of large fingerling rainbow trout. —, regression line; ——, limits of 95 per cent probability (2 standard deviations).

an r of 0.78 (Fig. 2). As can be seen from the scatter diagram, this correlation has a much better distribution and needs little qualification over the range covered by the observations. The two points falling outside the area of 95 per cent probability are experiments from Section C carried out in 1940. These two experiments, as well as another one planted with small rainbows, experienced unusually high mortalities indicative of disease or other limiting conditions. The three plantings were made in consecutive divisions of Section C.

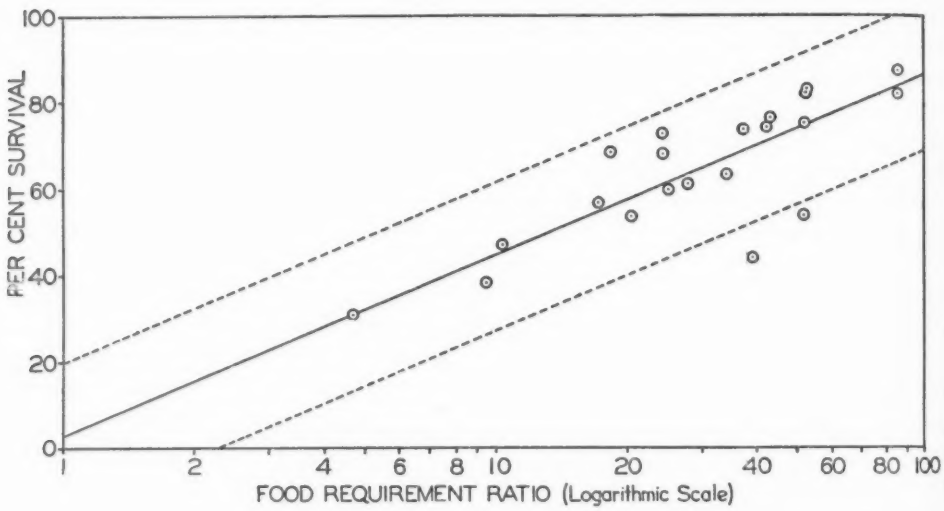

Fig. 2. Relation of percentage survival to food requirement ratio for 21 plantings of small brown trout. —, regression line; ——, limits of 95 per cent probability (2 standard deviations).

As stated above, partial correlation to eliminate the differences in size at planting indicated that the range in size was not sufficient to demonstrate significant differences in survival. Partial correlation with the rate of planting gave a coefficient of 0.82. The probability that this observed correlation was a chance selection from an uncorrelated population is considerably below 0.01 according to the table of Fisher (1932).

The observed correlations of this group do not differ significantly from those observed for the large rainbow fingerlings. For the simple regression, differences as great or greater would be expected 40 per cent of the time by Fisher's z test. The partial correlations are even more closely allied; a difference as great or greater would occur in 77 per cent of the cases under conditions of random sampling as shown by the z test.

SMALL FINGERLING RAINBOW TROUT

There were 14 plantings of these fish. The range of average size for the different lots was 1.32 to 1.69 inches in total length and 0.331 to 0.823 grams in weight. Stocking concentrations were

fairly uniform and ranged between 0.140 and 0.196 trout per square foot of water surface. Ten plantings were of 242 trout each and four of 181. The experiments were run for 84 to 132 days. The gross survival for all fish of this group was 44.2 per cent and the mean survival per planting was 42.7 per cent.

The resulting data yielded a correlation coefficient of 0.62 for the simple regression. Such a high coefficient would be obtained nearly once in fifty times by random sampling of an uncorrelated population; consequently it must be considered with caution. Fisher's *z* test shows that the coefficient is not significantly different from those for the other two lots; in fact, a difference as great or greater is to be expected in 39 per cent of the cases. Further analysis of this group was not made due to the questionable status of the simple regression. Since the concentration at planting was fairly uniform, no factor appears important enough to justify partial correlation.

TABLE 2.—SUMMARY OF EXPERIMENTS WITH SMALL FINGERLING BROWN TROUT

Expt. no.	Year	Survival (per cent)	Trout removed (grams)		Food ratio	Trout planted per square foot of water	Operation period (days)
			Planted	Wild			
1	1938	*76.2*	2,662.1	3,553.9	42.8	0.169	94
2	1939	*81.8*	2,198.0	380.1	85.3	0.180	110
3	1939	*82.6*	2,247.5	2,020.8	52.7	0.169	110
4	1939	*87.0*	2,520.5	429.0	85.5	0.047	109
5	1940	*53.5*	1,739.4	1,631.8	51.6	0.180	132
6	1940	*43.8*	1,252.4	1,902.6	39.3	0.169	132
7	1940	*30.7*	520.0	10,682.7	4.6	0.047	133
8	1941	*82.0*	323.6	293.1	52.5	0.033	102
9	1941	*68.0*	113.5	503.1	18.4	0.033	102
10	1941	*60.7*	871.0	2,278.7	27.7	0.090	108
11	1941	*73.6*	1,175.0	1,974.7	37.3	0.090	108
12	1941	*56.2*	693.5	3,346.3	17.2	0.084	105
13	1941	*72.3*	979.3	3,060.5	24.2	0.084	105
14	1941	*53.3*	1,370.5	5,301.3	20.5	0.047	120
15	1942	*75.0*	347.3	326.0	51.6	0.108	103
16	1942	*74.0*	283.5	389.8	42.1	0.108	103
17	1942	*67.9*	567.0	1,757.7	24.4	0.090	97
18	1942	*59.6*	581.2	1,743.5	25.0	0.090	97
19	1942	*46.8*	396.9	2,742.9	12.6	0.084	93
20	1942	*38.1*	297.7	2,842.1	9.5	0.084	93
21	1942	*62.8*	1,580.5	3,049.9	34.1	0.047	122
Means		*64.1*			36.1	0.097	108.5

BROWN TROUT IN SECTION E-1

To illustrate more clearly the type of data upon which the above correlations have been based, the gross data obtained from experimental plantings in Section E-1 are presented as a sample in Tables 3 and 4 and Figure 3. Four separate plantings of 261 fingerling brown trout were made in this 617-foot section from 1939 to 1942, inclusive.

To install screens and flashboards prior to planting on May 31, 1939, it was necessary to drain Section E-1. All wild trout in their second year and older were removed then, but it was

TABLE 3.—WILD TROUT REMOVED FROM STREAM SECTION E-1, 1939–42

	1939	*1940*	*1941*	*1942*
Experiment no.	4	7	14	21
Total wild trout removed	115	1,003	1,074	225
Wild fish under one year[a]	115	895	1,048	196
Wild fish over one year[b]	0	108	26	29
Brown trout	82	949	1,061	219
Rainbow trout	33	54	11	5
Eastern brook trout	0	0	2	1
Total weight of wild trout, ounces	15.2	376.8	187.0	107.6

[a] Total length about 2.75 inches.
[b] Total length, in inches: 1940, 7.4 (3.6–12.0); 1941, 7.1 (4.9–10.7), one 19 inches; 1942, 7.4 (4.3–11.5).

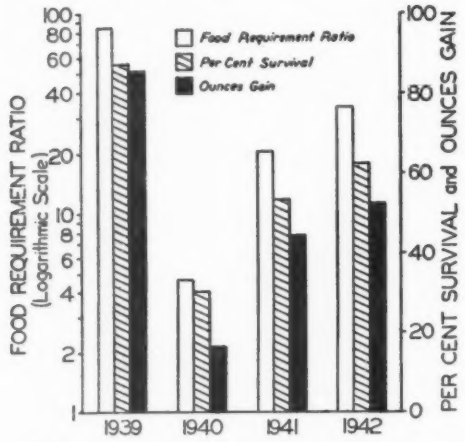

Fig. 3. Results of planting 261 fingerling brown trout annually in Section E-1, 1939–42.

impossible to remove yolk sac fry of the year that had hatched from eggs laid in the previous autumn. This was the source of the 115 brown trout fingerlings of the year removed at draining in 1939 (Table 4).

The results obtained in Section E-1 furnish ample evidence of the effect of competition and predation by wild populations on planted trout. The total weight of 115 wild fish removed in 1939 was 15.2 ounces (Table 3), while survival of planted fish was 87.0 per cent the same year (Table 4). The food ratio for the planted fish therefore was high, 85.5 per cent. In contrast, the total weight of wild fish removed in 1940 was 376.8 ounces, survival was low, 30.7 per cent, and the food ratio of the planted fish was very low at 4.6 per cent. Since the food ratios are on a percentile basis, the food ratios for wild trout are the differences between the above ratios and 100 per cent. Thus, the food ratio for wild trout was 14.5 per cent in 1939, and 95.4 per cent in 1940. A large population of wild trout was present in Section E-1 in 1940. Most of the 1,003 wild fish removed (Table 3) were brown trout in their first year, but of these, 108 could be considered as predators, and their presence was evidenced both in the survival and in the food ratio.

TABLE 4.—RESULTS OF PLANTING 261 HATCHERY-REARED FINGERLING BROWN TROUT IN SECTION E-1, 1939–42

	1939	*1940*	*1941*	*1942*
Experiment no.	4	7	14	21
Percentage survival	*87.0*	*30.7*	*53.3*	*62.8*
Date planted	5/31	5/9	5/29	5/26
Date drained	9/17	9/19	9/26	9/25
Days operated	109	133	120	122
Length at planting, inches	1.40	1.42	1.37	1.29
Length at draining, inches	4.05	3.24	3.74	3.73
Growth over period, inches	2.65	1.82	2.37	2.44

Additional evidence of the effect of heavy competition and predation by wild fish is seen in study of the growth of the trout planted each year. It will be noted (Table 4) that the brown trout planted in 1940 grew an average of 1.82 inches over the 133-day period of the experiment, while those planted in 1939 grew an average of 2.65 inches in only 109 days. Thus, under light competition in 1939, they grew 0.83 inches more in 24 days less time. Part of the faster growth resulted from slightly higher mean maximum water temperatures in 1939 (61.9°F.) as compared with 1940 (61.4°F.) for the same period.

SPECIFIC DIFFERENCES IN SURVIVAL

Comparison of Figures 1 and 2 indicates the rate of survival for the large rainbow is similar to that of the small brown trout; the regression lines have nearly identical slopes. This is not apparent from the raw data of the experiments. The gross survival, 63 per cent, for the brown trout appears much higher than that of the large rainbow, 47 per cent. Most of the difference is due to the greater competition to which the rainbow were subjected as indicated by the lower food ratios (Tables 1 and 2). A greater hardihood is nevertheless indicated for the brown trout, because they were much smaller at planting; the reason for this is not obvious. It is known that brown trout predominate in Convict Creek despite repeated plantings of rainbow in the same and adjacent water systems, but this condition may be the result of intensive angling as well as other factors. Schuck (1943) has shown that the return of brown trout to the creel does not correlate with population density of that species. It is well known that rainbow populations can be depleted by intensive angling. Inasmuch as angling was not a factor in these experiments, the most likely explanation lies in a greater inherent ability of brown trout to meet competition either among themselves or from other species of trout.

The difference in origins of the brown and rainbow stocks does not appear to be a determining factor. The large rainbow were reared in relatively warm water, whereas the small rainbow as well as the brown trout were reared in water similar in temperature to the experimental stream. Both stocks of rainbow experienced higher mortality, considering their size, than did the brown trout despite similar experimental treatment.

Since these experiments covered only the growing season, the question arises as to what mortalities might be expected during the winter.

WINTER CONDITIONS

Heavy snowfalls, accompanied by high winds and low water temperatures, create extremely serious hazards for fish life in high mountain areas. Observations at Convict Creek Station during February 1942 gave good proof of this fact. On cold nights when air temperatures fell close to 0°F., anchor ice formed on the bottom of riffles. Snow blown into the water by the wind drifted against the anchor ice until dams were formed. Water levels were raised as much as two or three feet behind these dams forming temporary pools. These would freeze over as did most of the pools. On clear mornings it was surprising how quickly the sun's rays would warm up the water, melt

away all anchor ice, surface ice, and snow dams, and again permit an unobstructed flow of water. Heat absorbed from the sun by the stream bed would raise water temperatures to 39° or 40°F., even though the air temperature remained lower than this all day.

Aside from cold water, ice, and snow dams, the greatest hazard to fish doubtless results from the deep snowdrifts that build up along the banks. These frequently break off into the water and probably smother many of the trout beneath them. Snow banks break off regularly in nearby trout rearing ponds, and on one occasion about 300 trout were picked up dead under a heavy drift.

Further proof of heavy winter mortality in trout was obtained by comparing fall and spring populations in a section of the main Convict Creek containing five pools and open to angling. The pools were sampled in three years at the end of August and end of April, after diverting the water and pumping the pools dry.

The number of fish decreased from 56.3 to 74.6 per cent between August and April (Table 5). In comparing these mortalities with those found experimentally for the growing season, at least three considerations must be kept in mind. First, the over-winter mortalities were sustained by all trout over three inches in total length while the experimental mortalities resulted among planted fish about 1.5 inches long. Second, the over-winter season is eight months and the growing season four months, but the expected mortality would be greater in the latter season from the standpoint of food competition. Third, over-winter mortalities can only be compared with experimental data on brown trout, because nearly all the wild trout are of this species. It is clear that over-winter mortalities of larger trout are high as compared with those obtained experimentally from smaller fish in the growing season. Reduction in numbers might result from migration, disease, predation, angling, or severe environmental conditions. There is no evidence substantiating any but the latter cause. Low temperatures combined with severe snow conditions in winter are believed to be the major cause of the disappearance of trout between August and April in Convict Creek.

TABLE 5.—WILD TROUT COLLECTED FROM FIVE POOLS IN CONVICT CREEK, 1939–42

Year	*Date sampled*	*Total taken*	*Trout*		*Decrease autumn to spring (per cent)*
			Brown	*Rainbow*	
1939	Aug. 30	158	151	7	—
1940	Apr. 29	69	68	1	*56.3*
1940	Aug. 30	241	238	3	—
1941	Apr. 30	61	61	0	*74.6*
1941	Aug. 30	272	264	8	—
1942	Apr. 30	79	79	0	*71.0*

Another significant matter emphasized by collection of wild fish, both from the experimental sections and by semi-annual sampling of wild populations in the main Convict Creek, is the importance of natural propagation. These data will be presented in detail later; recalculations from the figures in

Table 5 indicate that from 1,700 to around 5,000 young brown trout per mile of stream may be contributed annually.

APPLICATION OF THE EXPERIMENTAL FINDINGS

It is apparent from the results of these experiments that, during growth periods when food competition is a determining factor, the success of planting trout can be anticipated when the weight of the resident trout is known. This would apply only where fairly even environmental conditions prevailed over the growing season or where severe summer cloudbursts, floods, or factors other than competition and predation do not bring about serious additional losses. The weight of resident trout could be determined by any valid sampling method. The accuracy of predictions would be contingent primarily upon two qualifications. First, the trout to be planted must not be diseased or otherwise abnormal, and second, they should be planted at rates consistent with the productivity of the environment. The first qualification is self-evident, but the latter will bear discussion.

Only a certain amount of food is available in any one stream. Heavy stocking in streams having large populations of resident trout will increase the food demand beyond the supply and low survivals will result; the resident trout also will be less successful for the same reason. This latter fact cannot be emphasized too strongly. It cannot be assumed from any data presented here that heavier planting will insure a better final result. The food ratio concept applies equally well to resident trout, so that unless the stream is understocked or barren of fish, any increase in the success of plantings will be reflected in a decreased success of the wild fish. The success achieved will be evident from the resulting survival, from the condition of the fish, or from both of these criteria.

There is at least one other factor that complicates the prediction. In the analyses of results presented above, it was demonstrated by partial correlation that the rate of stocking or planting is an important factor. Its effect results from competition between individual fish in the same planting, since all other competition between the fish is measured by the food ratio. Thus a light planting would have greater success at a given food ratio than a heavy one, but the exact relationship between the planting rate and the food ratio is not measurable from data at hand. It is well known from practical planting experience that an increase in the density of planting usually results in increased survival up to a certain point beyond which survival decreases as intensity of stocking is increased. Chamberlain (1943) found this to be true from stocking experiments in streams of the Pisgah National Forest and many similar cases are reported in the literature.

With the foregoing qualifications in mind, Table 6 is presented giving predictions for the initial survival of brown trout based on data in Figure 2 and Table 2. It is evident that when 100 pounds of wild fish are present and the food ratio of planted trout is 5 per cent, low survivals may be anticipated. In contrast, when resident trout are scarce, much higher survivals can be expected. But even these rates may be considered

TABLE 6.—OVER-SUMMER SURVIVAL OF SPRING-PLANTED, 1.4-INCH BROWN TROUT FINGERLINGS, STOCKED AT RATE OF 5,000[a] PER MILE OF STREAM 10 FEET WIDE

Pounds of wild trout per mile	Food ratio[b] of planted trout	Expected survival[c]	
		Number	Per cent
5	50	3,680	*74*
10	33	3,315	*66*
15	25	3,055	*61*
20	20	2,855	*57*
25	17	2,690	*54*
50	9	2,145	*43*
100	5	1,560	*31*

[a] This rate is equal to the mean rate in the experiments with fingerling brown trout of similar size (Table 2); the range was 1,750 to 9,500 per mile of 10-foot stream.

[b] Based on 1,000 planted trout per pound.

[c] Initial survival only, i.e., through the first growing season following a spring planting.

of somewhat dubious value. When over-winter mortalities (Table 5) of from 50 to 70 per cent are added to those anticipated through the growing season, the end results are very few fish in return for the effort and money expended. These data confirm the fact that former stocking tables for fish of various sizes with set percentages of survival are badly in need of revision. Those presented by Embody (1927) and Davis (1938) did not consider either specific differences in survival as discussed above or the effect of wild populations. It is obvious, too, from the data presented here that mortality rates set up in previous tables need drastic revision. Evidence from creel census returns by many workers further confirms this need. The survivals, particularly of brown trout, reported here appear much higher than survivals indicated by creel census work. This, of course, is due to the greater length of time involved in the latter studies. No attempt will be made to offer revised tables now. That task will come later, following full-year operation of experimental streams and further study of anglers' catches.

We are, therefore, led to an obvious conclusion. Fingerling trout of a practical size cannot possibly provide significant additions to the creel when they are planted in waters having abundant populations of resident trout. This fact is even more obvious if it is remembered that the survivals obtained here cover only the one growing season that followed planting. No return to the creel could be expected until at least the following season, and, as outlined above, winter conditions may cause additional, and possibly greater, mortality. Consequently plants of fingerlings should be made principally in barren or depleted waters if any appreciable success is desired.

It can now be stated with confidence that by far the greater proportion of fish caught are the result of natural propagation. This statement would not apply to streams near to population centers where stocking for the creel is conducted with heavy plantings of large, legal-sized trout. Additional evidence of the importance of natural propagation is provided by the work of Randle and Cramer (1941) in Squaw Creek, a tributary of the Pit River in northern California. From creel census records following plantings of marked hatchery fish they found that naturally spawned rainbow trout furnished over 97 per cent of the trout taken each year. Natural propagation is of parallel imporance in eastern waters according to Shetter and Hazzard (1940: 466), who said: "In northern Michigan streams it seems evident that chief reliance must be placed upon the native stock to yield the bulk of angler's catch."

Planting of large legal-sized trout in intensively fished waters is the best known method of producing good fishing and at the same time securing adquate returns from the hatchery product. This discussion relates to other findings by Chamberlain (1943) as to the stocking of the intensively fished waters in Pisgah National Forest. In such waters he found that spring plantings of trout yield the most satisfactory increments to anglers. Autumn plantings of fish of nearly the same size produced only one-fifth as great an increment. What increment could possibly accrue from a plant of fingerlings that already had undergone a 70 per cent mortality by autumn? The presence of wild trout and the limited stream food supplies combine to prevent either high survival of hatchery fingerlings or growth of many to catchable size. Under such circumstances we have but one alternative, and that is to produce the poundage in hatcheries and plant large legal-sized fish as done in streams of the Pisgah National Forest.

Small 2-inch fish can be produced in hatcheries at one-fifth the cost of 6-inch fish. Survival rates previously established show that it is more economical to plant small fish to obtain any given number of fish creeled. The facts presented here, plus those from creel census work, clearly indicate the error in that concept. In the light of planting problems as we understand them today, the most efficient use of hatchery fish should be either for (a) the creel in heavily fished waters, or (b) natural reproduction in waters lightly or moderately fished or such suitable waters as are barren of trout. In the latter, the quality of the fishing will depend mainly on water temperatures, food, and spawning conditions. Fish managers might well determine how best to aid natural populations through improvement of the environment so that maximum sustained yields can be obtained.

SUMMARY

1. The survival of 63 experimental plantings of fingerling brown and rainbow trout under controlled conditions is reported for five seasons, 1939 to 1942, inclusive, at Convict Creek, California.

2. A method is described for the analysis of the effects of competition by wild trout on survival of planted fish; this embodies a food ratio that is shown to correlate with observed survivals.

3. A gross survival of 63.7 per cent was obtained for brown trout fingerlings, from 1.25 to 1.56 inches in total length. Larger rainbow fingerlings, 2.88 to 3.72 inches, under more severe competition, had a gross survival of 46.6 per cent. Other rainbows, of 1.32 to 1.69 inches, gave a gross survival of 44.2 per cent. These results were obtained in experimental periods of 89 to 151 days.

4. Plantings of fingerlings are largely ineffectual in streams containing numerous wild trout, since competition and predation prevent any significant survival.

5. Natural propagation adds large numbers of fish to stream stocks annually.

6. Heavy over-wintering loss of naturally propagated brown trout in their first year of life is clearly indicated.

7. The bearing of these findings on the stocking of streams is discussed.

LITERATURE CITED

CHAMBERLAIN, T. K. 1943. Overstocking fish streams. N. Amer. Wildl. Conf. Trans., 8: 350–359.

DAVIS, H. S. 1938. Instructions for conducting stream and lake surveys. U. S. Bur. Fisheries, Fishery Cir., **26**: 1–55.

EMBODY, G. C. 1927. An outline of stream study and the development of a stocking policy. Contrib. Aquicultural Lab. Cornell Univ. 21 pp.

FISHER, R. A. 1932. Statistical methods for research workers. London, Oliver and Boyd. 307 pp.

MORGULIS, SERGIUS. 1915. The body surface of flounders and its relation to the gaseous metabolism. Am. Jour. Physiol., **36**: 207–216.

NEEDHAM, PAUL R., and H. JOHN RAYNER. 1939. The experimental stream, a method for study of trout planting problems. Copeia **1939**: 31–38.

NEEDHAM, PAUL R., and F. K. CRAMER. 1943. Movement of trout in Convict Creek, California. Jour. Wildl. Mgt., **7**: 142–148.

RANDLE, ALLAN C., and FREDERICK K. CRAMER. 1941. The Squaw Creek Test Stream. Calif. Fish and Game, **27**: 172–184.

SCHUCK, HOWARD A. 1943. Population density of brown trout in Crystal Creek, New York, 1939–41. Jour. Wildl. Mgt., **7**: 18–23.

SHETTER, DAVID S., and ALBERT S. HAZZARD. 1940. Results from plantings of marked trout of legal size in streams and lakes of Michigan. Trans. Amer. Fish. Soc., **70**: 446–466.

TRELOAR, ALAN E. 1939. Elements of statistical reasoning. New York, John Wiley & Sons. 261 pp.

WEYMOUTH, F. W., JOHN FIELD II, and MAX KLEIBER. 1942. Relationship between body size and metabolism. Proc. Soc. Exper. Biol. and Med., **49**: 367–370.

WEYMOUTH, F. W., J. M. CRISMON, V. E. HALL, H. S. BELDING, and JOHN FIELD II. Total and tissue respiration in relation to body weight; a comparison of the kelp crab with other crustaceans and with mammals. Physiol. Zool. (in press).

WHITE, H. C. 1930. Trout fry planting experiments in Forbes Brook, P.E.I. in 1928. Contrib. Canad. Biol. Fish., N.S. **5**: 205–211.

FOOD HABITS AND MANAGEMENT OF AMERICAN SEA BRANT

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The sea brant or brant goose (*Branta bernicla*) is a game bird of superior quality, a unique and distinctive waterfowl, little known to most sportsmen and ornithologists. It is specialized and under more restrictions as to requirements of environment and food than any other common aquatic game species. The brant is truly pelagic or littoral, and its occurrence beyond sight or sound of the ocean and saline bays or estuaries is abnormal except in long migrations. It has been sharply reduced in numoers since 1931.

DISTRIBUTION

Recent taxonomic study indicates considerable intergradation in the three forms previously recognized as species, and the authors regard all the sea brants as races of one species. Peters (32) lists these and their respective distribution as follows:

"*Branta bernicla bernicla:* Breeds in northern Europe and Asia from Novaya Zamlya to the Taimyr Peninsula; Franz Joseph Land; Kolguev Island. Winters on the coasts of northwestern Europe.

"*Branta bernicla hrota:* Breeds in Arctic

America from 100° W. (110° W.?) south to 74° N., on both coasts of Greenland south to 70° N., and on Spitzbergen. Winters chiefly on the Atlantic coast of the United States from New Jersey to North Carolina, also on the coasts of northwestern Europe.

"*Branta bernicla nigricans:* Breeds on the Arctic coasts of Siberia from Taimyr Peninsula and New Siberian Islands eastward; Arctic America on the mainland east to Coronation Gulf and on the islands east to 110° W. (100° W.?). Winters on western shores of the Pacific south to Japan and northern China and from Vancouver Island to Lower California."

Recent data reveal some extensions of nesting and wintering ranges (Fig. 1). Frank Dufresne, of the Alaska Game Commission, reports concentrations at Dease Inlet, Harrison Bay, and Jones Island, and an isolated nesting colony at Azun River opposite Nunivak Island. Moffitt (23, 24) gives an unusual record near Buhne's Point, North Humboldt Bay, California, where individual broods were reared in 1940 and 1941. On July 27, 1940, 21 adults and four juveniles "about the size of a bantam chicken" were reported by State Warden L. E. Lahr and later confirmed by various bird students. The number of adults suggests they might have found suitable nesting habitat. On August 24, 1941, a pair with seven young, unable to fly, were reported in the same general locality. Efforts to collect a young bird were unsuccessful, so that positive assurance of nesting is lacking.

POPULATIONS

Since the sea brant is restricted to coastal saline waters during the winter and normally is gregarious, estimates of population usually can be made with greater accuracy than with more widely distributed species. A review of the records indicates that even in earlier times the brant population fluctuated markedly from year to year. During some years, and apparently at times for 2 or 3 years in succession, very few young are produced.

Because the brant nests in the far north—beyond the reach of all but an occasional explorer or Eskimo—the ancients believed the bird was bred from barnacles or boring sea-worms that attack wood.

The brant normally nests on lowlands adjacent to estuaries of the Arctic coast. These regions are subjected to extreme storms, and the nesting season (including the period for molting and rearing young to an age at which they can forage for themselves and make the long migration southward) must be telescoped into a short span of only 2½ to 3 months; hence some nesting seasons are relatively unsuccessful. Sudden storms may flood and destroy many nests or kill directly or indirectly the newly hatched goslings, resulting in great losses.

EAST COAST

Phillips (33) concluded from field studies and a review of gun-club records (particularly the Monomoy Brant Club, Chatham, Massachusetts) from 1863 to 1932, that the maximum population along the Atlantic seaboard of the United States would not exceed two-thirds of a million. In 1939 Harold Peters, Flyway Biologist of the Fish and Wildlife Service, estimated the total as about 75,000. There have been yearly fluctuations, but comparison of recent data with accounts of early naturalists shows progressive decrease since white settlement began. The eastern

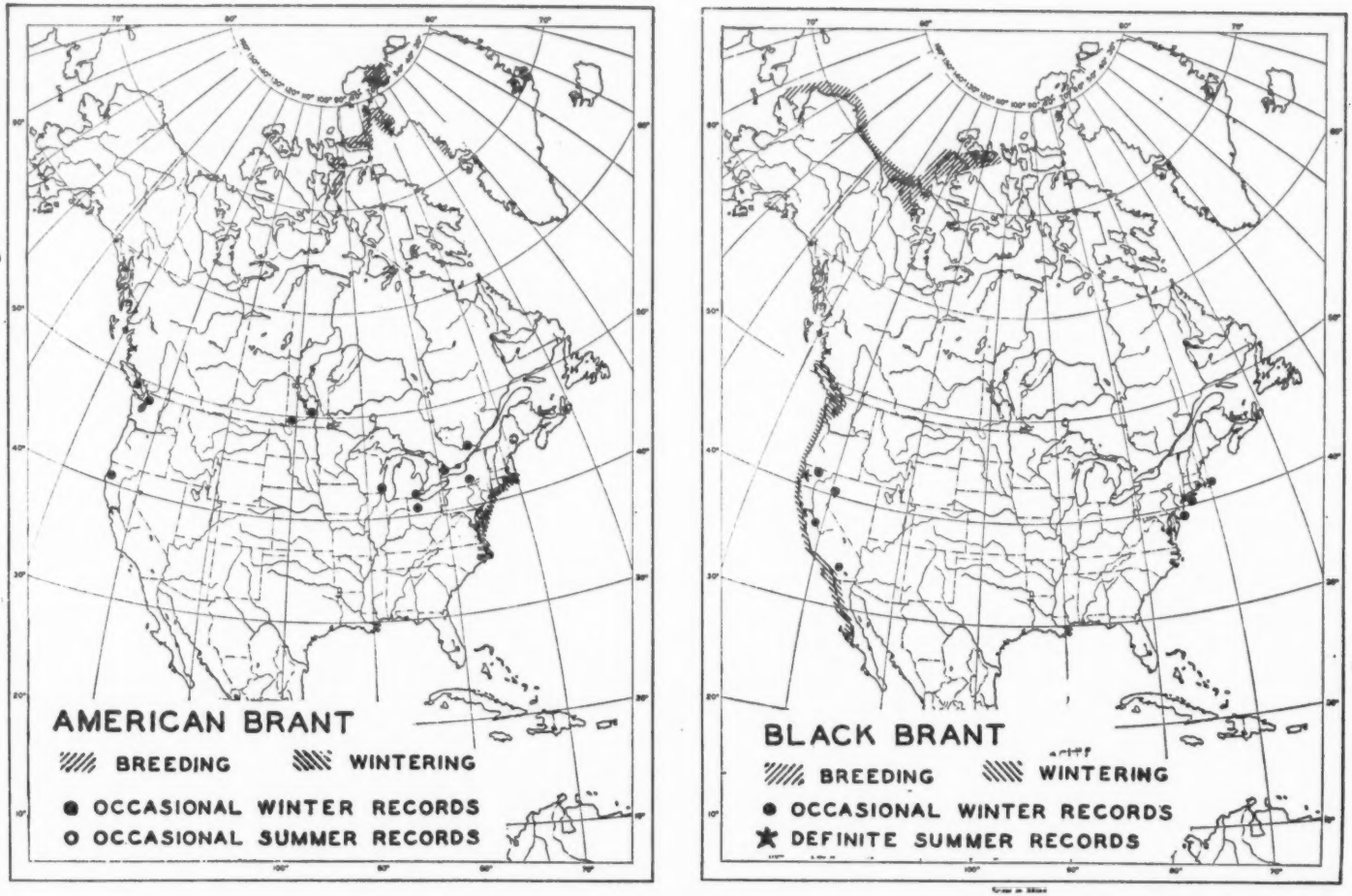


FIG. 1. Distribution of brant in North America (Prepared by F. C. Lincoln, U. S. Fish and Wildlife Service).

brant evidently reached a peak for recent years in 1925 and the west-coast bird in 1935.

The late Charles A. Urner recorded (letter, July 14, 1935) the following 1-day counts at favorable points along the New Jersey coast from Atlantic City through Barnegat Bay:

Winters	*Maximum 1-day Count*
1924–25	80,000
1925–26	15,000
1926–27	10,000
1927–28	15,000
1928–29	15,000
1929–30	12,500
1930–31	18,000
1931–32	6,000
1932–33	10,000
1933–34	2,000
1934–35	10,000

It may be assumed that Mr. Urner did not see all brant along the New Jersey coast, since he covered only such territory as possible by automobile or boat, or on foot. Since 1931 most of the brant wintering on the east coast have concentrated along the New Jersey coast. Previously large rafts of birds were reported in Pamlico Sound, North Carolina; lesser numbers were seen on the Virginia and Maryland coasts; and still smaller numbers in favorable, mild winters along Long Island, New York, and southern Massachusetts, particularly at Monomoy Point. A Federal waterfowl inventory covering most of the favorable wintering grounds along the east coast has been made each January, since 1936, under F. C. Lincoln, who summarized the data as follows:

Year	*Totals on East Coast*
1936	48,000
1937	56,000
1938	44,000
1939	72,000
1940	94,000

Wide variation in numbers from year to year is shown by records of the Monomoy Brant Club (Phillips, 33). These also demonstrate the remarkable powers of recuperation of the brant. Like other geese, the brant enjoy a relatively long life span and therefore can survive a few poor breeding years far better than the shorter-lived ducks. Peaks of spring abundance at Monomoy occurred in 1867, 1873, 1876, 1887, 1890, 1901, 1906; years of scarcity included 1865, 1877, 1882, 1886, 1895, 1900, 1903, and 1906 to 1909. In 1886 there was great scarcity, yet the club log for 1887 states: "Never a greater number of brant passed this point." For that year it was estimated that two-thirds of the birds were young of the previous summer. During the summers of 1932, 1933, and 1934, few young were produced. Of a number of flocks observed, only 3 to 7 per cent were young of the year. From 1932 to 1938 the Atlantic coast population was alarmingly small, the production of young being subnormal each season.

The encroachments of civilization and increased commercial navigation on bays and estuaries that formerly were feeding and resting areas for brant, together with overshooting, produced the gradual reduction prior to 1931. The period from 1931 to the present has been more critical, with abrupt and almost complete destruction of the extensive beds of eel-grass, which normally constitutes the principal food of the brant, along the entire east coast. In consequence, the population in 1933–34 was only about 10 per cent of that in 1930–31. Many concentration areas showed decreases of 90 to 98 per cent.

FIG. 1. Distribution of brant in North America (Prepared by F. C. Lincoln, U. S. Fish and Wildlife Service).

WEST COAST

Reliable totals are not available for the entire wintering population of west-coast brant. James Moffitt (14–25) and a group of cooperators made yearly censuses in February on the principal concentration points along the coast of California from 1931 to 1942. Although brant may winter from Vancouver Island and the Queen Charlotte Islands to Magdalena Bay, probably half of the total population winters along the California coast. The totals of these February censuses are as follows:

Year	*Totals along California Coast*
1932	43,946
1933	13,819
1934	29,968
1935	125,153
1936	66,055
1937	33,187
1938	59,520
1939	57,913
1940	75,412
1941	61,339
1942	64,703
Average	57,365

The great variations in these figures may not only reflect differing success in nesting, but also suggest that all birds along the coast were not counted at each census period. Brant movements during the winter are influenced markedly by both local and general weather conditions and by many other local environmental factors. Consequently the brant are often erratic in their movements and in selection of places for feeding. This makes it difficult to determine the total population over a wide coastal area.

Chester A. Leichhardt estimated (memorandum, November 22, 1940) that 20,000 or more brant winter along the Washington and Oregon coasts. R. S. Bach reported that during the first week of December, 1940, fully 60,000 brant were observed consistently in Samish Bay and another 40,000 were reported in an area adjacent to Dungeness Spit, Washington.

BANDING

Few brant have been banded, and only two returns are available. One (No. 37–722306), banded by C. E. Gillham at Okevik, Kendall Island, Mackenzie Delta, on July 19, 1937, was killed at Bodega Bay, California, on November 27, 1938. The other was a "station return," banded at Lake Merrit, Oakland, California, on February 1, 1927, and recaptured there on January 17, 1929.

LONGEVITY

Wounded adults, held in captivity 4 to 12 years, have been examined and declared in excellent health. James Moffitt (letter, April 16, 1941) reported a partly albinistic black brant (presumably the same individual) that visited Morrow Bay, California, each winter for more than 20 years.

MIGRATION

The migration of the Atlantic coast race has been ably summarized by Lewis (12); in going south the birds pass mainly east of Hudson Bay, to James Bay, and thence overland southeast toward the coast. Despite early reports by Hapgood (9) and others, it was believed formerly that the birds held strictly to the coast line in migration.

Brant are late migrants, and those birds that winter farthest to the south are the first to migrate north. Bent (1) reports that wintering birds begin to move northward in February and usually reach Great South Bay, Long Is-

land, in March. By the middle of April they are congregated off Monomoy, on the south end of Cape Cod, Massachusetts. Phillips (33) states that spring arrivals first appear at Monomoy about the second week of March, and the main concentration between March 25 and April 20. The few present after April 25 are either cripples or young that may linger into May. By June 1 many are at the mouth of the St. Lawrence River, and by the last of June the main population is settled on nesting sites in the far north. D. A. Déry of Provancher, Canada, states (letter, Feb. 5, 1943) that brant first appear in spring at Pointe aux Bouleaux, Province of Quebec, on the north shore of the St. Lawrence River, between March 30 and April 17; they depart from May 29 to June 12. Sutton (35) saw the first arrivals at Southampton Island on June 14, but most of them were later; the first nest with eggs was found there on June 25.

The southward return flight begins about the last of August, and by mid-November has reached the southernmost wintering grounds. On the east coast only stragglers go beyond southern North Carolina, whereas on the west coast some pass to Magdalena Bay, Lower California.

C. E. Gillham (unpublished field report) states that black brant were common 6 miles below Kashunuk village, lower Yukon Delta (in 1941), and more numerous there than in the western Arctic. He obtained evidence that they came down the Yukon River into that area in spring. He adds that on the spring migration they go across country, possibly from the east end of the Aleutian Islands and then inland to reach their nesting grounds, by overland flights of 300 to 400 miles.

That all do not follow this overland route is evidenced by the observations of Nelson (30) in 1881, in Alaska and the northwest Arctic. He wrote (p. 94–95) that on the shores of Bering Sea and the islands of the Alaskan coast the black brant occurred in such numbers during the spring as to afford better sport than all other geese combined. Nelson found many breeding east of Point Barrow.

The southward autumn migration follows the coast, often at considerable distance from land. In August, Gillham found large flocks paralleling the coast, 10 miles or more at sea, and flying toward Point Barrow. Nelson (31) reports Dall as seeing many 100 miles offshore. Along the coast of Alaska, Dufresne reports that they normally follow the coast line across St. Lawrence and Nunivak islands to the Aleutians; huge fall concentrations occur at Morzhovoi on the island just south of Nunivak. After leaving the Aleutians, the brant apparently proceed directly to the wintering grounds.

Moffitt (20–24) states that brant seldom arrive on California bays in shootable numbers before November 25; his earliest record for Tomales Bay was October 14. Gabrielson and Jewett (7, p. 129) state that brant do not appear on the Oregon coast in appreciable numbers until December or January; thenceforth, the numbers increase until they start north in April.

Apparently the west-coast birds migrate earlier than their eastern relatives—possibly a result of temperature differences. According to Nelson (31), they usually appear at the mouth of the

TABLE 1.—FOOD OF EASTERN BRANT, FROM STOMACHS COLLECTED PRIOR TO 1932
(All figures are percentages)

Date collected	State	Fullness of stomach	Vegetable food	Animal food	Gravel	*Zostera marina*	*Ruppia maritima*	Ulvaceae	Other algae	Corn	Plant fibers, drift	Mollusca	Balanidae and hydroids	Crustacea
Jan.														
1910	N. C.	Full	100	—	60	70	28	—	—	—	2	—	—	—
Mar.														
1905	N. C.	Full	100	—	40	100	—	—	—	—	—	—	—	—
1906	Del.	½	100	—	25	100	—	—	—	—	—	—	—	—
June														
1914	N. B.	¼	100	—	75	100	—	—	—	—	tr.	—	—	—
1928	Lab.	¾	100	—	64	100	—	—	—	—	tr.	—	—	—
Nov.														
1915	Mass.	Gorged	100	—	35	100	—	—	—	—	—	—	—	—
1915	Mass.	Full	97	3	35	74	—	17	—	—	6	3	—	—
1922	N. C.	Full	100	—	40	99	—	—	—	—	1	—	—	—
Dec.														
1911	Mass.	¾	100	—	80	100	—	—	—	—	—	—	—	—
1911	Mass.	Full	100	—	41	97	—	—	—	—	3	—	—	—
1911	Mass.	⅛	100	—	80	95	—	—	—	—	5	—	—	—
1913	E. coast	Full	100	tr.	30	92	8	—	—	—	—	—	tr.	—
1913	E. coast	½	100	—	25	92	8	—	—	—	—	—	—	—
1913	E. coast	¼	100	tr.	5	92	8	—	—	—	—	tr.	tr.	—
1913	E. coast	Full	100	—	20	94	6	—	—	—	—	—	—	—
1921	Mass.	Full	100	—	65	100	—	—	—	—	—	—	—	—
1921	Mass.	Full	100	—	65	100	—	—	—	—	—	—	—	—
1921	Mass.	¾	100	—	75	70	—	—	10	—	20	—	—	—
1921	N. C.	Full	100	—	14	96	—	—	—	1	3	—	—	—
1921	N. C.	Full	100	—	55	45	55	—	—	—	—	—	—	—
1921	N. C.	¾	100	tr.	78	85	15	—	—	—	—	—	—	tr.
1922	N. C.	¼	100	—	20	80	20	—	—	—	—	—	—	—
1922	N. C.	¼	100	—	—	38	62	—	—	—	—	—	—	—
1922	N. C.	¼	100	—	20	68	32	—	—	—	—	—	—	—
1922	N. C.	¼	93	7	50	74	8	—	—	—	10	7	—	1
1922	N. C.	¼	100	—	30	10	90	—	—	—	—	—	—	—
Oct.														
1915	Mass.	Full	99	1	37	98	—	—	—	—	1	—	1	—
Aug.														
1922	B. C.	Full	100	tr.	65	90	—	7	—	—	3	tr.	—	tr.
Averages			100	—	44	85	12	1	—	—	2	—	—	—

Yukon River between May 18 and 22, and most of them arrive within the next 10 days. Only a few follow the same route in the autumn.

FLIGHT

The flight during migration is noticeably different from the movements between feeding and resting grounds, in which they usually stay close to the water, in compact groups often with barely enough space between individuals to allow free wing strokes. Unlike the flocks of Canada geese, there seems to be no leader; apparently the flight is governed by group impulse. Flights may be made either as compact but unorganized units or as long serpentine

TABLE 2.—FOOD OF EASTERN BRANT IN STOMACHS COLLECTED SINCE 1932[a]
(All figures are percentages)

	January	April	May	June	Nov. (2), Dec. (11)	Average[b]
Number of Stomachs	21	7	29	10	13	80
States represented	N. C.	N. Y. Mass. Quebec	1–N. J. 28–Quebec	Quebec	8–N. Y. 3–N.J. 1–N. C. 1–Mass.	
Vegetable	99	100	93	85	100	95
Animal	1	tr.	7	15	tr.	5
Gravel	51	44	56	61	61	56
Zostera	24	tr.	—	—	13	9
Ruppia	60	tr.	—	—	—	16
Spartina	—	—	—	—	6	1
Gramineae	—	2	—	10	tr.	1
Misc. plant and drift	10	2	tr.	tr.	9	4
Ulva	—	57	10	24	33	17
Enteromorpha	3	27	26	8	27	19
Monostroma	—	—	tr.	—	—	tr.
Ulvaceae	—	—	2	10	—	2
Chaetomorpha	—	—	31	24	—	14
Cladophora	tr.	—	6	1	—	3
Cylindrocopsa	—	—	—	5	—	1
Chlorophyceae	—	—	4	2	—	2
Hormiscia	—	—	tr.	—	—	tr.
Phaeophyceae	—	—	1	—	—	tr.
Pylaiella	—	—	tr.	—	—	tr.
Fucus	—	—	tr.	—	—	tr.
Rhizoclonium	—	—	—	tr.	—	tr.
Plumeria	—	—	tr.	—	—	tr.
Holosocceon	—	—	tr.	—	—	tr.
Porphyra	—	—	tr.	—	—	tr.
Rhodophyceae	—	—	tr.	—	—	tr.
Undetermined algae	tr.	11	9	—	11	5
Mallotsus vallosus (eggs)	—	—	2	10	—	2
Pisces	—	—	tr.	—	—	tr.
Mollusca	1	tr.	tr.	—	tr.	tr.
Amphipoda	—	—	tr.	—	—	tr.
Balanidae	—	—	—	—	—	—
Capellidae	—	—	—	tr.	—	tr.
Misc. Crustacea	—	—	tr.	—	tr.	tr.
Hydrozoa: *Obelia*, etc.	—	tr.	—	—	tr.	tr.
Nereidae	—	tr.	4	4	—	2
Insecta	—	tr.	tr.	—	—	—
Misc. animal matter	tr.	tr.	—	—	tr.	tr.
Average number of items per stomach	4	4	4	2	4	

[a] Volume of food per stomach, mere trace to 27.5 cc.
[b] Average on basis of individual stomachs, without consideration of when taken.

strings. Nelson (29) aptly described their behavior as follows:

"A bird at either end of the flock rises or descends a few inches or several feet; and the movement is instantly followed in succession by every one of the companions till the extreme is reached and the entire flock is on the new level, or, it may be that a bird near the middle of the line changes its position, when the motion extends in two directions at once. These latter changes are made so regularly and with such rapidity that the distance between birds does not appear altered in the least, while a motion exactly like a graceful undulation runs the length of the flock, lifting or depressing it to the level of the originator of the movement."

Cottam observed a group departing from Great South Bay, Long Island, on April 2, 1934; the day was clear with a southwest wind, following an unusually cold period, and a rising tide covered the feeding beds. The birds were unusually noisy; when the first dozen rose from the water, they circled back and forth over the drifting but loosely scattered flocks. They went higher and higher, and when a sizeable flock had assembled and attained a considerable altitude, it departed easterly along the coast.

The wing strokes and flight are more rapid than those of any related species. In moving from one place to another, the birds follow the outline of the coast; even a low ridge usually is sufficient to turn their course.

FOOD AND FEEDING HABITS

Of all American waterfowl, the sea brant is perhaps the most specialized and least adaptable as to food and feeding habits. On wintering grounds it is confined mainly to shallow bays and estuaries with eelgrass (*Zostera marina*). Food preferences have been determined by field studies on the wintering grounds of both coasts, and by C. E. Gillham and J. J. Lynch who spent a summer on nesting grounds near the mouth of the Mackenzie River. To supplement these studies, stomachs were collected and analyzed at the Patuxent Wildlife Research Laboratory. Published data and supplementary information from other workers also have been assembled here.

The laboratory studies revealed the food of birds on the Atlantic coast before the eelgrass disappeared, to have been very different from that of specimens collected subsequently (compare Tables 1 and 2). Under normal conditions during the migration and winter period, the eastern brant is almost entirely a vegetarian and feeds almost exclusively upon eelgrass, which constitutes more than 85 per cent of the diet. This submerged marine or brackish water seed plant affords a nearly balanced non-breeding diet for the brant. The luscious buried rootstocks (rhizomes) are eagerly sought, but the long, green ribbonlike leaves are taken most commonly; leaves more than 30 inches long have been found neatly folded in brant stomachs. In the southern part of the range of the eelgrass (as in coastal North Carolina) the plants are small and resemble the closely related wigeongrass (*Ruppia maritima*), which also grows in shallow coastal bays frequented by brant. Wigeongrass is prominent in the diet of brant in their southern winter range, averaging 12.14 per cent of the food during the migration and winter period. Algae, mostly sea lettuce (Ulvaceae), formed only one per cent of the food used. Undetermined or comminuted plant material

(much probably eelgrass) and drift made two per cent of the average meal. Animal foods, probably taken accidentally or incidentally with more delectable foods, formed less than one per cent and consisted of small gastropod mollusks (often attached to eelgrass), hydroids (*Obelia geniculata*), crustaceans, and insects. A few kernels of bait (corn) were taken by one bird. No appreciable variation in the food was noted during different months of the winter.

The remarkable difference in food used since the sudden drastic reduction of eelgrass in 1931 is summarized in Table 2.

On the west coast eelgrass was not affected until about 1938 and then only in a minor degree as compared with the east coast conditions. At no time in the memory of man has eelgrass been unobtainable on the west coast, although it is now less abundant than formerly in many bays and estuaries. Table 3 summarizes the food of the western brant (*B. b. nigricans*).

The food consumed in January differs

TABLE 3.—FOOD OF WESTERN BRANT
(All figures except volumes are percentages)

	December	November	Other Months[a]	Average[b]
No. of stomachs	40	15	10	65
States represented	5–Ore. 3–Calif. 32–Wash.	Calif.	5–Alaska 1–B. C. 4–Calif.	5
Average volume (cc.)	27.7 food 8.5 grit	9.0 food 6.8 grit	60.0 food 7.0 grit	
FOOD				
Vegetable	99	99	100	99
Animal	1	1	tr.	1
Gravel	64	48	57	60
Zostera	98	53	24	76
Phyllospadix	tr.	44	14	12
Sedges, grasses	—	—	38	6
Undetermined plant materials	tr.	1	4	1
Ulva	—	—	5	1
Enteromorpha	—	—	2	tr.
Ulvaceae	tr.	1	3	1
Chaetomorpha	—	—	10	1
Chlorophyceae	—	tr.	—	tr.
Fish eggs	tr.	—	—	tr.
Amphipoda	tr.	—	tr.	tr.
Balanidae	—	—	tr.	tr.
Misc. Crustacea	tr.	tr.	—	tr.
Hydrozoa	tr.	1	tr.	tr.
Insecta	tr.	—	tr.	tr.
Misc. animal matter	tr.	—	tr.	tr.
Average number of items per stomach	1	2	2	2

[a] January, 2; March, 1; April, 1; May, 3; June, 1; July, 1; September, 1. Birds of late spring, summer, and early autumn taken as migrants off the Alaskan coast.
[b] Average of individual stomach percentage for all months.

considerably from that in succeeding months (Table 2). The stomachs used for this month were taken in 1933 in Pamlico Sound, North Carolina, while there was still some eelgrass, and more wigeongrass occurs there than in most bays of the Atlantic coast. It is logical therefore that considerable wigeongrass and eelgrass should have appeared in the diet for January. The small amount or complete absence of these foods in the stomachs for other months substantiates field observations on the scarcity of these preferred foods along the Atlantic coast.

As the availability of these plants decreased, there was a corresponding increase in the consumption of sea lettuce and other algae and of grass and sedge-like plants. Most of the birds that had fed upon the latter materials were emaciated, and rarely was one found with a full stomach—which may suggest low palatability as well as low nutritive value for these substitute foods. One bird had swallowed a 7 by 10-inch piece of sea lettuce. The flesh of birds that feed upon algae to a considerable extent is not palatable, whereas that of brant fed on eelgrass and wigeongrass is most delectable. Birds able to obtain their preferred food made a meal of one or two items, but those unable to do so apparently gleaned from a greater variety. Because brant are rarely found far from the ocean, it is natural that the various species of algae and particularly sea lettuce should enter prominently into the diet as substitute foods; few of the higher plants (except eelgrass and wigeongrass) grow in the saline waters within their range. Considering the almost complete depletion of eelgrass along the Atlantic coast, it is surprising that brant could find enough of this plant after January, 1932, to form even 8.5 per cent of their average meal. The writers have on various occasions since January, 1932, raked miles of sea coast without (in some instances) finding even a single living plant.

Eelgrass is also the preferred food of the west-coast birds (Table 3). As it became less abundant there (even though its denudation nowhere exceeded 50 per cent of the original supply), there was a corresponding increase in consumption of rockgrass (*Phyllospadix*). This plant is more fibrous and tougher than eelgrass (to which it is closely related) and grows in the more rocky areas of the Pacific Coast. Eelgrass is a plant of the firm muck or semi-sandy bottoms. Rockgrass does not occur on the Atlantic coast. The Alaskan birds were migrants taken where eelgrass was not very abundant (Table 3). The food of these birds resembled somewhat that of birds on the nesting grounds, with a higher consumption of grasses and sedges (average, 38 per cent). More animal food is consumed when eelgrass is scarce, and slightly more animal food is taken as the birds proceed northward to the nesting grounds. A higher protein diet is undoubtedly required during and immediately preceding the nesting and molting seasons, which may account for the increased consumption of animal food. Marine worms (Nereidae) and fish eggs were the most important animal items; small gastropod mollusks, soft-bodied crustaceans, hydroids, and various other marine invertebrates were of lesser importance. Undoubtedly many fish eggs and small invertebrates were taken accidentally, as many were found

adhering to eelgrass in the stomachs. Some, however, were taken purposely: more than 6,000 fish eggs were found in one stomach from California, and many were found in stomachs from Quebec in which there was no plant fiber upon which the eggs could have been attached. Three brant collected during May in coastal Quebec by Dr. D. A. Déry had consumed 51, 49, and 43 nereid worms, respectively; a bird taken from North Carolina had consumed more than 60 small gastropods (*Bittium* sp.).

The amount of food and gravel or fine sand in the gizzards varied considerably. All stomachs contained sand, although a number of them had little or no food. The percentage of gravel was computed on the basis of the entire stomach content, while the total food without the gravel was considered 100 per cent. In accordance with the standard practice of the Fish and Wildlife Service laboratories, percentages were based upon volume rather than upon frequency of occurrence. In some birds the gullet, as well as the gizzard, was gorged. The full stomachs contained 60, 27, and 22 cc. of food and 7, 8.5, and 5.5 cc. of gravel, respectively; both the gizzard and proventriculus in these cases was distended. The average contents of 85 measured stomachs (many with little food) was 6.9 cc. of food and 5.2 cc. of gravel. The gravel content was usually greater in birds taken after the disappearance of eelgrass, possibly indicating need for more grinding material to pulverize the cellulose of algae —or perhaps the gravel was taken to appease hunger. Fine sand usually constituted nearly half the volume of stomach contents. One intestine contained 49 cc. of fine sand, an almost incredible amount, and in addition there were many tapeworms throughout its length. Apparently the fine gravel had been effective in dislodging and preventing the worms from forming an obstruction. A considerable number of other intestines contained tapeworms; specimens were identified as *Hymenolepsis setigera* by Dr. Wilford Olsen of the U. S. Bureau of Animal Industry. Most of them were lodged between the third and paired caeca, the largest number being near the third. Birds with an excessive number of worms also had much sand in the intestine. Nearly all of the intestines contained parasites of some kind. This suggests that sand may, in general, have been taken to clean the intestines of parasites. A few gizzards contained gizzard worms (nematodes).

Field observations on food habits support the laboratory findings that eelgrass is the preferred food. The brant can dive, but none was ever seen to do so in feeding on this plant. Instead, they obtained it through tipping, swimming, or walking in shallow water. Normally they feed during the last half of the ebb or the first half of the flood tide, when the eelgrass beds are uncovered or under only a few inches of water. When most of the feeding birds have their heads below the surface of the water, there are always a few sentinels on duty to warn the flock of any impending danger. Sometimes at high tide, when the feeding grounds are flooded too deeply, the birds glean fresh eelgrass from shore drift.

When food became scarce, the birds fed commonly in the wake of or in company with diving ducks, particu-

larly redheads and scaups. The brant snatched ravenously all bits of eelgrass or wigeongrass loosened by the divers, and fought for plant food held in the bills of the latter. Brant often followed an oyster dredge that pulled up eelgrass and other submerged plant food in the course of its operations. Several times, when little such food was available, they fed on sea lettuce and other algae; and when an insufficient quantity of this second-rate food was at hand, the birds were forced ashore by hunger to feed on the salt flats. Cordgrass (*Spartina alterniflora*), bent hay (*S. patens*), and saltgrass (*Distichlis spicata*) were commonly taken to supplement the diet of algae. In the period of brant famine the birds were seen alighting in grass meadows or upland areas 100 to 200 yards from water—an observation rarely reported previously.

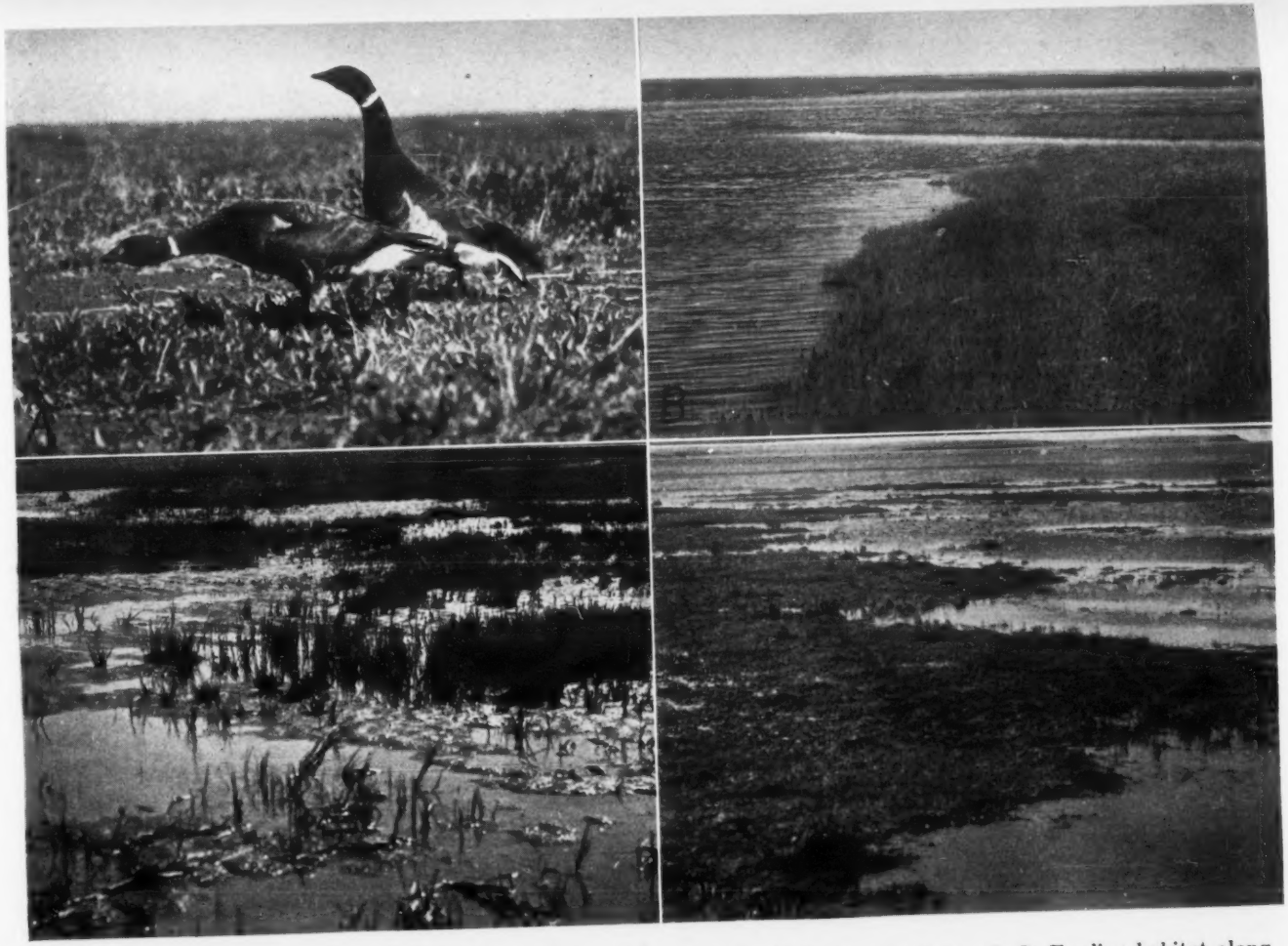
In a study of 25 lots of brant droppings taken near Brigantine, New Jersey (where there was no eelgrass and little or no wigeongrass), in March, 1936, Lynch found that about 60 per cent of the diet was sea lettuce (Ulvaceae) and the remainder of rootstocks of cordgrass.

J. A. Munro, Chief Conservation Officer for British Columbia (letter, August 26, 1939), stated that five stomachs of birds collected at Parksville, Vancouver Island, British Columbia, in January and February, 1934, were filled exclusively with eelgrass. T. H. Scheffer (letter, September 7, 1940), stated that eelgrass beds were not much in evidence during the highest tides of the preceding winter near the Willapa Refuge, Seaview, Washington; the brant then fed extensively on seaside arrowgrass (*Triglochin maritima*).

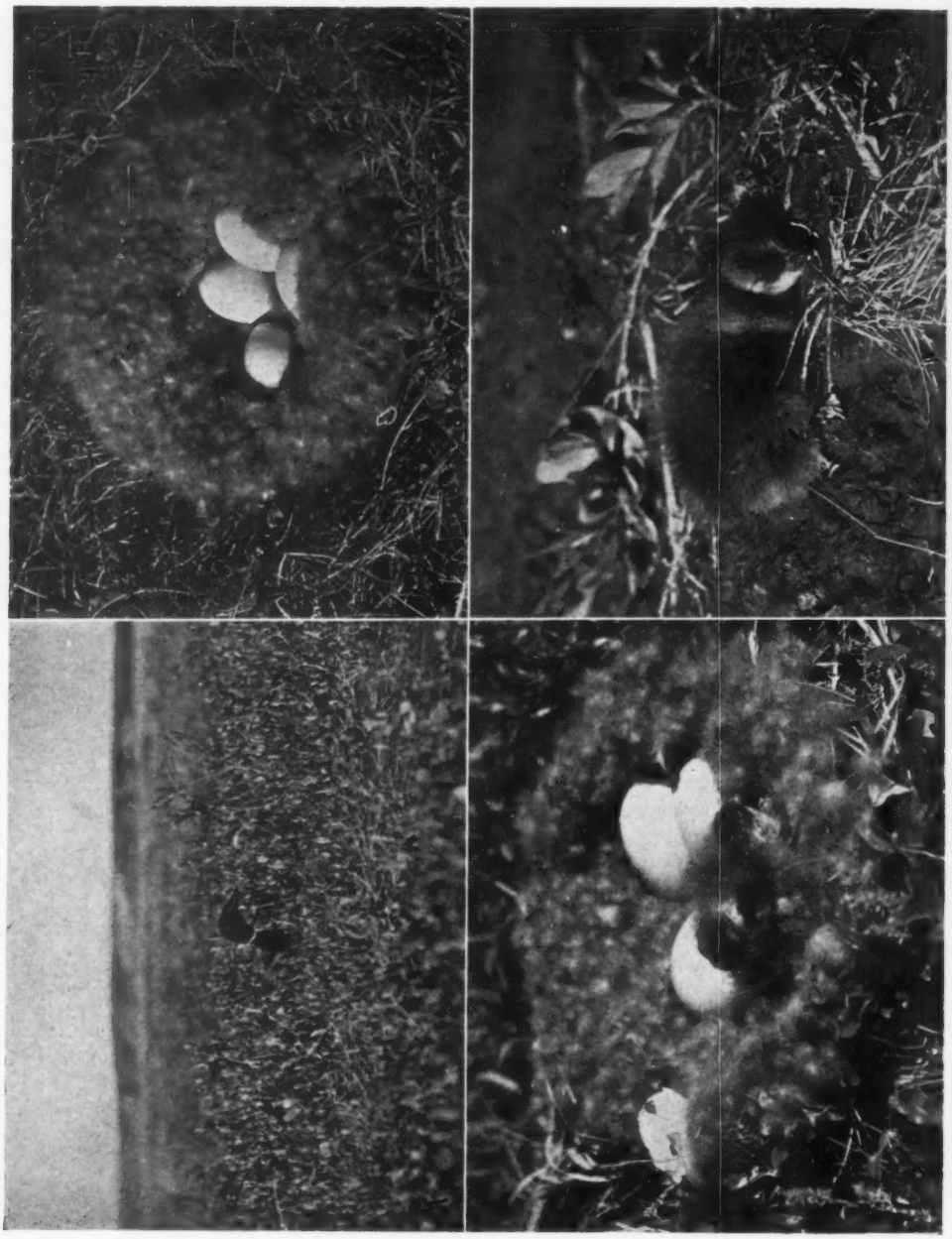
Moffitt (24, p. 228) pictures 56 brant feeding on a golf course near Pebble Beach, Monterey County, California, and others near Morro Bay, San Luis Obispo County, feeding on glasswort (*Salicornia*). The latter food is relished by Canada geese and various ducks, but normally is not taken by brant. In recent years, many observers on both coasts have reported brant feeding on newly sprouted grass after the manner of Canada geese.

In captivity, brant become accustomed to various kinds of grain, including corn, barley, oats, and wheat, mixed occasionally with a small amount of chopped green foods. When ample natural food was available, they would not take cereal bait; however, they did so during the time when there was the greatest scarcity of natural food. Once they became accustomed to the grains, these seemed to be relished.

According to Bent (1, p. 244), the brant, in addition to feeding extensively on eelgrass, devour "the fronds of some species of algae, crustacea, mollusca, worms and marine insects." Bent quotes Gatke at Heligoland as saying that when the sea is calm little companies will approach the cliffs and pick off the small mollusks and crustaceans. He also states that MacMillan found some of the first spring arrivals of brant on Baffin Land feeding on the black lichens which grow on the rocks. Mackay (13) had some captive birds that fed avidly on eelgrass, sea lettuce, freshly cut grass, and cultivated grain, especially whole corn; after almost every mouthful they drank from a pan of fresh water, although the wild birds in the neighborhood had no opportunity to obtain fresh water.



Black Brant. *A*. Pair of adults in low Arctic willow (*Salix anglorum*). *B*. Nesting habitat. *C*, *D*. Feeding habitat along pond shores. Photos by John J. Lynch, near Kendall Island, delta of Yukon, Canada, July, 1940.



Black Brant. *A.* Adult on nest. *B.* Typical nest in *Salix anglorum* and *Dupontia fischeri*. *C.* Eggs and newly hatched young in typical nest. *D.* Two-day-old gosling, just after leaving nest. Photos by John J. Lynch, near Kendall Island, delta of Yukon, Canada, July, 1940.

Black Brant. *A.* Adult on nest. *B.* Typical nest in *Salix anglorum* and *Dupontia fischeri*. *C.* Eggs and newly hatched young in typical nest. *D.* Two-day-old gosling, just after leaving nest. Photos by John J. Lynch, near Kendall Island, delta of Yukon, Canada, July, 1940.

John St. Yokum, Canada, July 1940.

Moffitt (letter, April 16, 1941) stated that brant off the California coast commonly feed on herring eggs attached to eelgrass and the birds develop a "fishy" taste after December 31 because of this habit.

Sutton noted (35, pp. 41–44) that birds collected at Southampton Island in August had "eaten vegetable matter, grass and roots, which they found along the edge of the lakes."

(37) states that brant on the breeding grounds ate grass, algae, moss, and stalks and leaves of Arctic plants (*Eriophorum, Ranunculus, Cerastium, Oxyria,* and *Saxifraga*), and the young fed on Gramineae and *Oxyria.*

INTESTINAL MEASUREMENTS

Measurements were made of the intestines of five males, nine females, and six of undetermined sex collected and

TABLE 4.—MEASUREMENTS OF DIGESTIVE TRACT IN 20 BRANT FROM QUEBEC (Centimeters)

Sex Number	Male 5	Female 9	Unknown 6
Intestine, from gizzard to vent	223(186–270)	221(189–249)	235(208–259)[a]
Gullet, from gizzard to mouth	26(23–30)	25(17–30)[b]	26(21–29)
Long axis of gizzard	—	—	3(2–4)[b]
Paired caeca	19(15–22)	20(16–24)	19(16–22)[a]
	18(13–21)	19(16–21)	18(15–20)[a]
Large intestine from paired caeca to vent	12(10–15)	12(11–16)[a]	20[c]
Third (rudimentary) caecum	0.7(0.5–0.9)	0.7(0.3–0.8)[a]	0.8(0.6–0.9)[d]
Caecum to gizzard	—	—	84[c]
Intestine, from third caecum to paired caeca	—	83(79–91)[a]	96[c]

[a] 5 specimens; [b] 2 specimens; [c] one specimen; [d] 3 specimens; [e] 4 specimens.

Forbush (6) reports an observer who found brant feeding on frozen quahogs (*Venus mercenaria*) one winter on the Massachusetts coast. He adds that in the far north they eat mosses, lichens, stalks, and many Arctic plants, also grass and berries, mollusks, and other small marine animals; in captivity they feed readily on corn and other grains.

Burdette (2) found that brant fed on moss and algae. Some early workers (27) erroneously believed that the brant subsisted commonly on fish. Dall and Bannister (5) reported the stomach of a bird collected in coastal Alaska, September 28, 1867, full of crustaceans. Van Dyke (36) found only eelgrass in the stomachs he examined. Witherby

sent to us by Dr. D. A. Déry of Quebec (Table 4).

WEIGHTS

Neithammer (28) states that six males (*bernicla*) weighed 1,415 to 1,730 grams (3 lb. 4 oz. to 4 lb.), and one female weighed 1,202 grams (2 lb. 12½ oz.). The general condition of a bird markedly alters its weight; most weights of eastern brant (*hrota*) unfortunately were taken when food was scarce and the birds in poor flesh. Of 26 males, collected by Dr. Déry near the mouth of the St. Lawrence River and reportedly in nearly normal condition, the weights were 2 lb. 9 oz. to 4 lb., and averaged 3 lb. 5½ oz. Fourteen fe-

males from the same area weighed 2 lb. 4 oz. to 3 lb. 11 oz. and averaged 2 lb. 15 oz. Five unsexed birds from Monomoy, Massachusetts, taken in March, 1889, averaged 3 lb. 5½ oz. Three taken by F. H. Kennard averaged slightly under 3 lb., and another (much emaciated) weighed only 1½ lb. Kortright (11) writes that one male weighed 3 lb. 3 oz. and three females 2 lb. 3 oz. to 2 lb. 11 oz., averaging 2 lb. 6 oz. Five male black brant (*nigricans*) averaged 3 lb. 10 oz. and ranged from 2 lb. 14 oz. to 4 lb. 14 oz. One female weighed 2 lb. 9 oz. Six unsexed birds averaged 3 lb. 3 oz., ranging from 2 lb. 14 oz. to 3 lb. 8 oz.

BRANT ON THE NESTING GROUNDS

On the nesting grounds brant occur only in close proximity to the sea. The nesting range is restricted to a narrow strip along the Arctic coast of the North American mainland and the periphery of Arctic islands.

We have no information about the eastern breeding grounds of the Atlantic brant (*B. b. hrota*) other than that in the literature. Soper (34) has described the grass tundra of the blue goose nesting ground he discovered on Baffin Island and noted that brant stop there during their spring migration to feed with the geese.

The Mackenzie River delta is one of the more important breeding areas of the brant. This vast section extends beyond the Arctic limit of trees, so that the outermost islands where nesting brant are found lie in the Tundra or Barrens region. These deltaic islands are low and marshy, replete with swales and ponds. Innumerable river channels meander among the islands, carrying in flood seasons the sediments that serve to build up and extend the delta. Sand bars and mud flats occur at the mouths of the various channels and along the shores of newly forming islands. The somewhat monotonous landscape is relieved only by occasional islands elevated above the recent delta deposits. The innermost of these high islands have been completely surrounded by delta marsh and grass tundra. More distal islands, such as Kendall Island, retain their identity but are fringed with grassy flats representing both direct river deposition and sea-tide deposits of sediments brought down by the river.

The sand bars and mud flats of the outer delta serve as resting places for brant. Adjacent shallow bays attract flocks of non-breeding brant and swans, particularly where the water is clear enough to permit growth of pondweed (*Potamogeton vaginatus*). In general, the habits of non-breeding adults in summer and of pre-migration flocks in early fall suggest the familiar routine of brant on their wintering grounds. Nesting birds adhere to quite a different routine and prefer the small swales and ponds of delta islands to the open bays.

NESTING

Each island is rimmed by a low but perceptible bank of firm soil representing the natural levee of adjacent river channels or, in some cases, a low beach formed by sea tides. These banks are only slightly above sea level and remain soggy all summer because of capillary moisture from the thawing subsoil; their vegetation is mostly of herbaceous marsh plants, and woody species are represented only by willows. An erect willow (*Salix alaxensis*), 3 to 5 feet high,

is the only tall vegetation of the outer delta islands. The prostrate Arctic willow (*S. anglorum*) forms low mats in some places and trails vinelike through the drier grass lands. The latter willow furnishes excellent nesting cover for brant and its catkins and leaf-buds are important as food, particularly during the early part of the nesting season when little other green vegetation is available.

Grasslands cover the low banks and pond borders. Nesting brant are partial to the pond shores and prefer to nest on the grassy islets abounding in such situations. A soft grass (*Dupontia fischeri*) is the predominant member of the grasslands and the favorite nesting cover of the brant. River sedge (*Carex aquatilis*) and the cotton sedges (*Eriophorum angustifolium* and *E. scheuchzeri*) mingle with *Dupontia* in damp places. Mosses and lichens are conspicuously absent from this grassland. A word of explanation is in order, as these plants usually predominate in tundra vegetation. Soper (34), in describing the grass tundra of Baffin Island, noted that the blue geese, when feeding, dug up and discarded much tundra moss to get to the roots of their principal food plant, *Carex stans*. The nesting islands of the brant in the Mackenzie region, however, are situated in an active river delta and subject to inundation and deposition of new soils during each river flood season. Sea tides cover these islands with salt water during Arctic storms, at the same time depositing older alluvium that tidal currents have dislodged from the bottoms of adjoining bays. Thus clays and other mineral soils predominate on the islands, and this factor (together with occasional flooding by sea water) inhibits the development of organic soils such as characterize true tundra. In more mature portions of the delta, where river deposition is confined to channel banks, the soils become increasingly organic in the interior. Tussock bogs, in which *Carex* and other sedges are dominant, quickly replace the original river marsh in such places; these bogs are followed by the appearance of mosses, lichens, and heaths indicative of true tundra vegetation.

The nest of the brant is probably the most beautiful of waterfowl nests. Grass is used only for the foundation and the nest proper is a thick, symmetrical ring of pure down, 14 to 18 inches in diameter. Probably three times as much down is used by the brant as by the snow goose. The powder-blue, slate, and steel-gray tones of this down make an admirable setting for the four or five eggs, which are faintly glossy white or soft ivory. The brant's feathers and down are reported to make the finest filling for pillows and feather bedding. The nests usually are well-hidden, but the incubating female often is poorly concealed because the Arctic grasslands have not put forth new growth when the brant starts to nest in early June. Arctic willows then may have some new foliage, but its prostrate stems rarely exceed 10 inches in height on many of the nesting islands. The incubating bird, nevertheless, is quite inconspicuous from a distance and may cover her nest and steal away when approached. Often it is possible for an observer to approach close to a nest without being seen. When finally he is observed, the bird invariably raises her head. Then, sensing danger, she slowly lowers her head and

neck and squats horizontally on the nest, becoming almost invisible. Then it is possible to approach within 15 yards of the nest without flushing the hiding female.

FEEDING GROUNDS

The interior depressions of the nesting islands contain innumerable ponds, varying in size from small grassy swales to moderately large lakes. Many of the smaller ones undoubtedly have been created by the intensive feeding of lesser snow geese and whistling swans. Submerged aquatic plants include pondweed (*Potamogeton vaginatus*) and mare's tail (*Hippurus vulgaris*).

Brant use the open ponds to some extent and feed on pondweed. They are more partial, however, to the shallow swales and grassy pond margins where Arctic oat-grass (*Arctophila fulva*) is conspicuous, growing in 5 to 10 inches of water. This plant is one of the principal foods of the swan and snow goose, but we could find no evidence of its use by the brant. The latter prefer the short grasses and sedges that form a zone margining the water; of these, *Carex aquatilis*, *C. concolor*, and *Eriophorum opacum* are the principal brant foods. *Carex concolor* comprised 92 per cent of the stomach contents in three brant collected in this feeding habitat, the balance was *Dupontia fischeri*. Other plants conspicuous along pond borders but not utilized by brant include: *Equisetum variegatum*, *Triglochin maritima*, *Juncus arcticus*, and *Ranunculus* spp.

Nesting brant and their young feed mainly by grazing on moist land or in shallow water. Nesting birds graze along pond borders and in drier grasslands, provided there is an abundance of tender foliage and the cover is not too dense; this is somewhat of a departure from their feeding habits in winter. Only the non-breeding adults are aquatic feeders during the nesting season. Brant are attracted to low flats frequently washed by storm tides, where tall vegetation is sparse; low mats of *Puccinellia paupercula* are eagerly grazed by both young and adults. The dense grasslands preferred for nesting are relatively unattractive for feeding, but the brant feed occasionally near the abandoned nests of snow geese. The latter usually clear an area 10 to 12 feet in diameter while gathering material for their bulky nests, and removal of the mat of old grass accelerates new growth in the cleared area. This provides succulent green browse for both geese and brant. Ice cakes stranded on the banks of islands during the break-up and subsequently removed by high tides also serve to remove the old grass mats. New growth of *Dupontia fischeri* and *Carex aquatilis* is apparent in these clearings and furnishes early pasture for the geese and brant before the normal summer growth has emerged from under the mat of the previous season.

Field observations and laboratory analyses of 70 brant droppings from the nesting grounds showed the consumption of foods to be about the following order: *Carex concolor*, *Salix anglorum*, *Dupontia fischeri*, *Puccinellia paupercula*, *Carex aquatilis*, and *Potamogeton vaginatus*. Field observations revealed that *Carex concolor* and *Dupontia* were excellent for both adults and young, especially late in the season. Earlier in the season, *Salix anglorum* seemed to be preferred.

NESTING BEHAVIOR

Gillham, (1939 *MS* report), writes that

"Black Brant are usually much wilder when approached on the nest than the Lesser Snow Goose. The female is attended by the male, but he is not as solicitous as the male goose. He usually swims about in the vicinity but several cases were noticed where the female chased her mate away from the nest. Any other brant, duck, goose, swan, loon or gull, that approached the mother brant on her island was immediately chased away by her. Two birds rarely nest on the same little island. The female brant quickly covers her nest with down when approached, and departs rapidly."

NESTING SUCCESS

The brant enjoys a measure of freedom from the perils that most Arctic nesting birds must undergo. The lesser snow goose, with which the brant shares the nesting islands we studied, is preyed upon by jaegers, glaucous gulls, Arctic foxes, and owls, and to some extent by the Eskimos. The inconspicuous coloration of the brant, its preference for dense nesting cover, and its habit of hiding the nest, all tend to protect it from winged enemies. Ground marauders cannot commit wholesale destruction on the dispersed nests of the brant to the extent that they can on colonial nesters such as the snow goose. We found few brant nests destroyed during 1940 and concluded that losses caused by natural predators are not greatly significant in management of the species.

There is, however, one grave and ever-present danger to the nesting success of the brant. The Arctic regions are notorious for their foul weather. Storms may arise any time during the breeding season, driving sea tides over the low nesting islands. Soper (34) mentions storms as a factor affecting populations of the blue goose. Forbush (6) suggests that the yearly numerical fluctuations of wintering Atlantic brant denote destruction of nests and young by Arctic storms. Gillham and Lynch found the brant in the Mackenzie region to have had a favorable nesting season in 1940, but a storm had disrupted early nests of the snow goose on the islands under observation. Many "two-story" goose nests were found on low areas with one or two eggs in the bottom compartment. Numerous stray eggs were seen, some along the driftline of storm wrack, suggesting that they had been washed out of early nests. Others probably were dropped at random by laying females whose nests had been destroyed. These geese renested, however, and brought off a successful hatch during the first week in July. As most brant nests hatched between July 10 and 13, it was believed that the nesting season for this bird did not get under way until after the storm. Had this storm occurred when the nesting season was well advanced, wholesale destruction of brant nests and young doubtless would have resulted, because Arctic summers are too short to permit renesting when the first nests are lost late in the season. Brant nests, furthermore, are more exposed to flooding than those of snow geese. The snow goose usually nests on the highest banks of the delta islands, whereas the brant prefers to nest on low islets where usually a rise of only 6 inches in the water level will destroy many nests.

During his Arctic expedition in 1939, Gillham found 83 black brant nests

containing an average of 4.96 eggs: 24 had four eggs; 38, five; and 21, six. No predation upon adults was noted, but one nest was destroyed by a jaeger. A considerable loss of nests was sustained by the snow geese, which may have acted somewhat as a buffer to protect the brant. The superior courage and fighting ability of the brant also give it better protection.

MANAGEMENT PROBLEMS

Little can be done about management on the Arctic nesting grounds. Predation normally is light. There appears to be little destruction by Eskimos because the birds are widely dispersed during nesting and molting, and cannot be herded or captured by the natives. Relatively few are shot by the latter. Regulation of hunting in the concentrated migration and wintering areas may be one of the best management tools. The abolition of spring shooting and closure of hunting on the east coast in 1933 in response to reduced numbers of the birds, shows that Federal and State authorities were aware of this problem and resolved to protect the species. Prohibiting the use of "sink boxes" and of live decoys also has done much to protect the species.

Brant shooting is a sport to challenge the most seasoned gunner and therefore is well worth perpetuating. Moderate hunting should be allowed whenever the population is sufficiently large. It is imperative, however, that reasonable protective laws be enforced, and that the prohibition of night-shooting and of spotlighting be continued. As a protective measure, rest areas should be established on the principal shooting grounds.

Any improvement in the eelgrass situation will favor the brant directly; hence studies on transplanting and improving the supply of this plant should be continued. Efforts to control the oil menace also are important to protect these gregarious coastal birds. Vigilance in the latter, especially during the war period, is particularly desirable.

BRANT SHOOTING

Brant shooting, although unexcelled as a sport, is enjoyed by relatively few persons because the birds are localized. Most epicures agree that the flesh is among the most savory of all waterfowl when the birds fatten on their favored eel grass. The meat is often considered inedible when the birds have fed extensively on algae, fish eggs, or other secondary foods, normally consumed in limited quantities, and especially when they are in poor flesh because of such feeding.

Under full protection and when not disturbed, brant become confiding and unsuspicious, but with only a little persecution they become one of the wariest of wildfowl. Then they seek the broad and isolated flats, and if pursued too severely, form in rafts on the sea at night.

Formerly, these birds were hunted and killed extensively from sink-boxes and floating batteries, and by the use of many live and wooden decoys. Before proper protection was afforded, they were hunted also at night in the broad bays and sounds by the aid of jacklights.

Now they commonly are shot from sunken boxes or "hides" on sand bars and points; when much hunted, decoys are of little attraction. As with most

waterfowl, the immatures are less wary and most easily decoyed. During storms when the brant fly low along the shore they decoy best. The most successful hunting, however, is done from offshore flats, on points, and in channels. Due allowance must be made for their vagaries and their propensities to do the unexpected. They are most alert and suspicious, and rarely hold a straight course when crossing a sand spit. They are thoroughly gregarious and in flight or on water usually crowd together closely. To the seasoned brant-shooter, there is an unexcelled charm about gunning for them. Good and complete accounts of gunning brant are given by Burdette, (2) Grinnell (8), and Heilner (10).

LITERATURE CITED

1. BENT, A. C. 1925. Life histories of North American wildfowl. U. S. Nat. Mus. Bul., 130: 237–258.
2. BURDETTE, WILLIAM. 1929. American duck, goose and brant shooting. New York, G. Howard Watt Publ. Co., p. 397.
3. COTTAM, CLARENCE. 1935. The eelgrass shortage in relation to waterfowl. Amer. Game Conf. Trans., 20: 272–279.
4. ———. 1934. The eelgrass situation in 1934. Amer. Game Conf. Trans., 21: 295–301.
5. DALL, W. H., and H. M. BANNISTER. 1867. List of the birds of Alaska, with biographical notes. Chicago Acad. Sci. Trans., 1: 295.
6. FORBUSH, E. H. 1925. Birds of Massachusetts and other New England States. Boston, Mass. Dept. Agr., 1: 296–299.
7. GABRIELSON, I. N., and S. G. JEWETT. 1940. Birds of Oregon. Corvallis, Oregon State Coll., pp. 128–129.
8. GRINNELL, G. B. 1901. American duck shooting. New York, Forest and Stream Publ. Co., pp. 66–71.
9. HAPGOOD, W. 1875. Brant geese (*Anser bernicla*—Linn.): their habits, migration, breeding places. Forest and Stream, 5: 49.
10. HEILNER, V. C. 1939. A book on duck shooting. Philadelphia. Penn. Publ. Co., pp. 187–206.
11. KORTRIGHT, F. H. 1943. Ducks, geese and swans of North America. Washington, D. C., American Wildlife Institute, p. 382.
12. LEWIS, H. F. 1937. Migrations of the American brant. Auk, 54: 73–95.
13. MACKAY, G. H. 1893. Stray notes from the vicinity of Muskeget Island, Mass. Auk, 10: 370–371.
14. MOFFITT, JAMES. 1931. First annual black sea brant census in California. Calif. Fish and Game, 17: 396–401.
15. 1932. Second. Calif. Fish and Game, 18: 298–310.
16. 1933. Third. Calif. Fish and Game, 19: 255–263.
17. 1934. Fourth. Calif. Fish and Game, 20: 355–364.
18. 1935. Fifth. Calif. Fish and Game, 21: 343–350.
19. 1936. Sixth. Calif. Fish and Game, 22: 295–300.
20. 1937. Seventh. Calif. Fish and Game, 23: 290–295.
21. 1938. Eighth. Calif. Fish and Game, 24: 341–346.
22. 1939. Ninth. Calif. Fish and Game, 25: 336–342.
23. 1940. Tenth. Calif. Fish and Game, 26: 381–389.
24. 1941. Eleventh. Calif. Fish and Game, 27: 216–233.
25. 1942. Twelfth. Calif. Fish and Game, 28: 19–28.
26. ———, and CLARENCE COTTAM. 1941. Eelgrass depletion on the Pacific coast and its effect upon black brant. U. S. Fish and Wildlife Service, Wildlife Leaflet, 204, p. 26. Mimeo.
27. MORTIMER, KERRY. 1874. Zoology of the Northwestern Territories. Forest and Stream, 3: 129–130.
28. NEITHAMMER, G. 1938. Handbuch Deutschen Vogelkunde, Leipsig, Aka-

demische Verlags Gesellschaft, p. 410.
29. NELSON, E. W. 1881. Habits of the black brant in the vicinity of St. Michaels, Alaska. Nuttall Ornith. Club Bull., 6: 131–138.
30. 1883. Cruise of the Corwin in Alaska and the Northwest Arctic Ocean in 1881. Washington, D. C., Government Printing Office, pp. 94–95.
31. 1887. Report upon natural history collection made in Alaska between the years 1877 and 1881. Arctic Series of Publications, Signal Service, U. S. Army, Government Printing Office, Washington, D. C. 49th Cong. 1st Sess. Misc. Doc. 156, No. 3, pp. 87–89.
32. PETERS, J. L. 1931. Check-list of birds of the world. Cambridge, Mass., Harvard Univ. Press, 1: 149–150.
33. PHILLIPS, J. C. 1932. Fluctuation in numbers of the eastern brant goose. Auk, 49: 445–453.
34. SOPER, J. D. 1930. The blue goose. Ottawa, Canada. Dept. of Int., p. 40.
35. SUTTON, G. M. 1932. The exploration of Southampton Island, Hudson Bay. Carnegie Mus. Mem., 12, Pt. 2, Zool. Sect. 2—Birds of Southampton Island, pp. 41–44.
36. VAN DYKE, T. S. 1883. Hills and streams of southern California. American Field, 19: 226–227.
37. WITHERBY, H. F., *et al.* 1939. Handbook of British birds. London, H. F. & G. Witherby Ltd., 3: 214–215.

SATISFACTORY WAR-TIME RATIONS FOR PHEASANT CHICKS[1]

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The experiment reported here was outlined (winter of 1941–42) when scarcities of ingredients used in rations for poultry and game birds were just being recognized. Critical ingredients then high in cost or difficult to obtain were dried milk products, meat scraps, and fish meals. Subsequently the quantities of these products available for livestock and poultry rations have been limited by government regulation. Thus it is difficult to maintain high feeding standards. The most promising procedure appears to be replacement of as much of the animal protein feeds as possible with more plentiful plant protein feeds.

Some of the nutritive requirements of ring-necked pheasants (*Phasianus colchicus torquatus*) have been determined. Callenbach and Hiller (1933) found their protein requirement to be about 28 per cent. Norris and others (1936) obtained greatest growth with 30 per cent of protein in the ration, but levels down to 24 per cent gave satisfactory results. The mineral tolerance of pheasants was found by Skoglund (1938) to be about the same as that of chickens. The requirements for vitamin D (Baird

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and Greene, 1935) and for riboflavin (Norris, 1934) for pheasants are higher than for chickens.

Wheeler (1899) found that during early stages of growth, chicks of the domestic fowl ate more and grew faster on a ration with about 40 per cent of the protein from animal sources than on other rations containing smaller percentages of animal proteins and uncorrected for phosphorus and other mineral elements. Growth was both excellent and economical when bone ash was used in rations of high plant and low animal protein content. With ducklings, however, results were poor with supplemented and unsupplemented high plant protein rations. In the work reported by Wheeler, gluten meal and O. P. (old process) linseed meal were used as plant protein replacements for animal meal.

Phillips, Carr and Kennard (1920), working with chickens, reported growth with vegetable protein feedstuffs comparable to those with meat scraps if the rations were balanced properly for mineral content.

Funk and Kempster (1940) found soybean oil meal superior to either cottonseed meal or corn gluten meal for stimulating growth of turkeys when each was fed at a 10 per cent level. More recently, Irwin and Kempster (1942) tested the value of soybean oil meal in rations for broiler chickens. Levels of soybean oil meal up to 25 per cent of the total ration produced satisfactory gains when combined with 2 per cent or more of an animal protein supplement.

Since other workers found soybean oil meal to be a satisfactory substitute for some of the animal protein concentrates for chickens and turkeys, it seemed reasonable to assume that it could serve similarly as a partial source of protein in pheasant rations. The researches here reported tested, under practical rearing conditions, pheasant starting rations that contained approximately 28 per cent of protein, largely from ingredients readily obtainable under war-time conditions.

PROCEDURE

Eight groups of 125 day-old ring-necked pheasant chicks, hatched on May 7, 1942, were reared to six weeks of age in 10×12-foot colony brooder

TABLE 1.—COMPOSITION OF THE RATIONS FED
(To each was added: salt, 0.5 lb.; cod liver oil, 0.25 lb.; and $MnSO_4$, 0.0125 lb. Each ration totalled 100.7625 pounds)

GROUP	1	2	3	4	5	6	7	8
Ground yellow corn	14.5	15.0	14.0	13.0	13.0	12.0	10.0	17.0
Wheat flour middlings	12.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Wheat bran	15.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Ground oats	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Alfalfa leaf meal	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Dry skim milk	7.5	—	—	—	—	—	—	—
Dried whey	—	10.0	10.0	10.0	10.0	10.0	5.0	5.0
Dried brewers' yeast	—	—	—	—	—	—	3.0	3.0
Meat scrap (50% protein)	10.0	20.0	16.0	12.0	8.0	5.0	3.0	12.0
Menhaden fish meal	8.0	—	—	—	4.0	2.0	2.0	3.0
Soybean oil meal	17.5	20.0	25.0	30.0	30.0	35.0	40.0	25.0
Bone meal	—	—	—	—	—	1.0	1.0	—
Ground limestone	—	—	—	—	—	—	1.0	—

TABLE 2.—CHEMICAL ANALYSES OF RATIONS FED (IN PERCENTAGES)

Group	1	2	3	4	5	6	7	8
Moisture	8.43	7.93	8.48	8.56	8.31	7.86	8.89	8.92
Ash	8.34	10.62	9.74	8.60	8.12	7.97	7.88	8.41
Protein	29.31	27.56	28.38	28.25	28.31	28.56	29.00	29.06
Ether extract	5.09	4.68	4.32	3.85	4.03	4.31	3.23	4.59
Fiber	6.39	5.78	5.87	6.23	6.30	6.24	6.81	6.25
Calcium	1.72	2.08	2.46	1.65	1.48	1.31	1.40	1.67
Phosphorus	1.26	1.33	1.46	1.15	1.09	1.03	0.92	1.20
Manganese	.0076	.0068	.0074	.0076	.0070	.0084	.0068	.0076
Ca:P ratio	1.37:1	1.56:1	1.68:1	1.43:1	1.36:1	1.27:1	1.52:1	1.39:1

houses with attached sunporches. The houses were equipped with electric brooders and the usual accessory equipment for satisfactory brooding. The chicks were weighed as groups when placed in brooding quarters and wing-banded individually when 2 weeks old. They were weighed individually at 2, 4, and 6 weeks of age, on scales sensitive to 1 gram, and at each weighing were examined for symptoms of perosis and condition of feathering. Records were kept of daily mortality and weekly feed consumption.

The rations offered (Table 1) were available in suitable feeders at all times. Water and chick-size insoluble grit also were supplied. The grit was sprinkled on the mash at each feeding. The electric brooders were removed at the end of the fourth week, when the beaks of all birds were clipped to control cannibalism.

The ration fed Group 1 contained 17.5 per cent of soybean oil meal in combination with dry skim milk, meat scraps and menhaden fish meal; this has been recommended for general use by Stadelman, Murphy, Callenbach and Boucher (1941). In each of the seven other rations, dry skim milk was replaced by dried whey or a combination of dried whey and yeast. The fish meal was omitted entirely from the rations of Groups 2, 3 and 4, the protein being supplied by variable proportions of meat scraps and soybean oil meal. In all other rations the protein carriers—menhaden fish meal, meat scraps, and soybean oil meal—were used in various combinations. The total protein content of all rations was calculated to be 28 per cent. Exact chemical analyses are given in Table 2.

RESULTS AND DISCUSSION

All the rations tested produced satisfactory game birds. The average body weights (Table 3) were normal for ring-necked pheasants at the ages indicated. At six weeks of age, Groups 1, 5, 6 and 8 were slightly heavier than the other four, but none of the differences is statistically significant.

A factor of considerable importance in game bird production is the quantity and quality of feather development and maintenance, described here as feather condition. In this respect Group 7 ranked first, closely followed by Group 1. The feathering of Groups 2 to 6 was about the same. The birds of Group 8 were poorest in feather condition at six weeks of age, due almost entirely to feather picking. Birds in all groups were feathered sufficiently for release.

TABLE 3.—AVERAGE INDIVIDUAL BODY WEIGHTS (GRAMS).

Group	1	2	3	4	5	6	7	8
Day-old	21	21	21	21	21	21	21	21
2 weeks	63	62	62	61	64	63	63	69
4 weeks	167	152	156	155	164	160	154	175
6 weeks	296	279	282	275	297	293	269	294

TABLE 4.—FEED CONSUMPTION PER 100 BIRDS (POUNDS)

Group	1	2	3	4	5	6	7	8
Week								
1	11.8	10.9	10.8	11.2	11.0	11.4	11.4	11.7
2	19.4	19.8	19.7	19.3	20.0	19.5	19.1	18.7
3	25.6	25.7	26.9	27.0	29.3	27.6	26.9	26.4
4	37.3	36.6	37.8	38.1	36.2	39.0	39.2	38.1
5	43.1	43.0	44.0	44.6	46.9	44.7	43.0	43.6
6	50.2	52.7	54.4	55.0	56.6	59.2	53.6	53.0
Totals	187.4	188.7	193.6	195.2	200.0	201.4	193.2	191.5

TABLE 5.—POUNDS OF FEED REQUIRED TO PRODUCE ONE POUND OF GAIN

Group	1	2	3	4	5	6	7	8
Period, weeks								
0–2	3.4	3.4	3.4	3.4	3.3	3.4	3.3	2.9
2–4	2.7	3.1	3.1	3.2	3.0	3.1	3.3	2.8
4–6	3.3	3.4	3.6	3.8	3.5	3.5	3.8	3.8
0–4	2.9	3.2	3.2	3.2	3.1	3.2	3.3	2.8
0–6	3.1	3.3	3.4	3.5	3.3	3.4	3.5	3.2

TABLE 6.—WEEKLY MORTALITY PER GROUP OF 125 CHICKS (PERCENTAGES)

Group	1	2	3	4	5	6	7	8
Week								
1	2.4	0.8	3.2	0.8	0.8	3.2	0.0	0.0
2	0.0	0.8	0.0	2.4	0.8	4.0	0.0	0.0
3	1.6	0.8	0.0	0.0	0.0	0.0	0.8	0.0
4	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0
5	0.8	0.0	0.0	0.8	0.8	1.6	0.0	0.8
6	0.0	0.8	0.0	0.0	1.6	0.0	0.8	0.8
Total	4.8	4.0	3.2	4.8	4.0	8.8	1.6	1.6

The variation in total consumption of feed was very slight among groups (Table 4), the widest being 7 per cent between Groups 1 and 6. None of the differences is significant. Group 1 was most efficient in feed utilization, but variations between groups were not of sufficient magnitude to be of primary importance; Groups 4 and 7 were least efficient (Table 5).

Mortality by weekly periods is given in Table 6. The mortality in Group 6 during the second week was caused by crowding in corners of the pen. Only

two chicks were lost by cannibalism, both in Group 5 during the sixth week. Livability in all groups was quite satisfactory, being best in Groups 7 and 8 where only two chicks each were lost during the entire six weeks.

The quality of the birds in all groups was excellent. There were no signs of perosis or dietary deficiency in any group and no stunted birds were found at the end of the experiment.

The results indicate that in pheasant starting rations soybean oil meal can replace large proportions of the usual animal protein supplements and that dried whey or a combination of dried whey and brewers' dried yeast can replace dry skim milk.

SUMMARY

Eight groups of 125 ring-necked pheasant chicks were reared to six weeks of age on as many different rations. Records were kept of daily mortality, weekly consumption of feed, bi-weekly weights, and feathering condition.

All the rations tested, including one with 40 per cent of soybean oil meal, were excellent for rearing, indicating a much wider range of tolerance with respect to sources of proteins than anticipated.

The selection of any one of the rations reported should be based primarily on availability and relative cost of the ingredients specified.

LITERATURE CITED

BAIRD, F. D., and D. J. GREENE. 1935. The comparative vitamin D requirements of growing chicks, turkeys and pheasants. Poul. Sci., **14**: 70–82.

CALLENBACH, E. W., and C. A. HILLER. 1933. The artificial propagation of ring-necked pheasants. Pa. Agr. Expt. Sta. Bul., **299**.

FUNK, E. M., and H. L. KEMPSTER. 1940. The use of vegetable protein concentrates for raising turkeys. Missouri Agr. Expt. Sta. Bul., **414**.

IRWIN, M. R., and H. L. KEMPSTER. 1942. The value of soybean oil meal in broiler rations. Missouri Agr. Expt. Sta. Bul., **441**.

NORRIS, L. C. 1934. Some studies of nutritive requirements of pheasants. Amer. Game Conf. Trans., **20**: 304–310.

NORRIS, L. C., L. J. ELMORE, R. C. RINGROSE, and G. BUMP. 1936. The protein requirement of ring-necked pheasant chicks. Poul. Sci., **15**: 454–459.

PHILLIPS, A. G., R. H. CARR, and D. C. KENNARD. 1920. Meat scraps versus soybean proteins as a supplement to corn for growing chicks. Jour. Agr. Res., **18**: 391–398.

SKOGLUND, W. C. 1938. The mineral requirements of ring-necked pheasant chicks. Unpublished data.

STADELMAN, W. J., R. R. MURPHY, E. W. CALLENBACH, and R. V. BOUCHER. 1941. Dry skim milk in ring-necked pheasant chick rations. Game Breeder and Sportsman, **46**: 102, 103, 114–116.

1941. A comparison of pheasant starting rations under practical commercial conditions. Pa. Game News, **12**(5): 4, 5, 28, 29.

WHEELER, W. H. 1899. Animal food for poultry. N. Y. Agr. Expt. Sta. Ann. Rept., **18**: 75–124.

CENSUSING PHEASANTS BY DETONATIONS

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A study of the ecology and management of the ring-necked pheasant (*Phasianus c. torquatus*) was begun in Nebraska in the spring of 1941. Prime among the objectives of the survey was to devise some method by which the populations could be estimated or counted. In conjunction with roadside counts as practiced in Minnesota, Iowa, Ohio, Pennsylvania and other states, attempts were made to derive a closer estimate than by that method. Every game technician working with roadside counts of pheasants realizes the difficulties involved. Having had success in estimating the numbers of mourning doves by counting their calls (McClure, H. E., Journ. Wildl. Mgt. 3: 323–328, 1939) a similar study of the calling of pheasants was undertaken. Throughout the summer of 1941 it was found that an average rooster in morning and evening, while establishing, feeding in, or surveying his grounds, would call at intervals of approximately 2 minutes. During these observations it was noted that these birds responded by crowing following thunder, blasting, or the explosions of shot guns. Even such noises as the slamming of a car door or banging on a metal tub would stimulate them to crow.

An attempt was made, therefore, to devise a method whereby this peculiar response could be utilized. Four sizes of aerial bombs, commonly called Day-go bombs, were purchased from a fireworks company. The volumes of explosive used in these bombs is at present a military secret, but they cost 10 to 50 cents apiece. In preliminary tests, observers were placed at one quarter, one half, and one mile intervals in various directions from the bombs. It was determined that pheasants would respond by crowing to these explosions at distances up to three miles or more. For practical purposes the 10-cent bomb had the advantage of not being so loud as to deafen the observer's ears, but loud enough to stimulate the birds for a mile or more. With all sizes of bombs, pheasants less than 200 yards away were frightened into silence. In calm weather birds crowing more than a mile away may be heard. Firecrackers placed on the ground did not elicit as uniform a response from the birds, nor did the discharge of a shot gun. This is explained by the fact that sound travels upward and outward from a fire cracker, and is directed forward by the gun. The explosion from an aerial bomb travels downward and outward, simulating thunder, and it results in a more uniform response. The most critical weather condition from the standpoint of the observer is the presence and amount of wind. Wind carries the sound of the bomb away, prevents distant calls from reaching the observer, and whistles by the observers' ears so that he cannot hear nearby calls. A simple rule is not to attempt to stimulate the birds by these bombs when there is a wind strong enough (about 5 miles per hour) to blow out the match used to light the fuse. In Nebraska there usu-

TABLE 1.—RESPONSES OF PHEASANTS TO BOMBS, BY MONTHS

Month	*Number of shots*	*Average responses per shot*	*Number of 1-minute counts*	*Average calls per minute*
January	0			
February	27	30.7	—	—
March	34	20.2	28	12.7
April	5	12.0	35	22.0
May	13	12.1	—	—
June	53	5.4	87	8.7
July	28	6.7	95	4.4
August	27	3.0	15	0
September	27	6.7	—	—
October	37	5.5	—	—
November	20	4.9	—	—
December	6	2.9	—	—
Total	277	11.0		

ally is wind from within an hour after sunrise until an hour before sunset; hence no tests were run during the midday hours. The majority of the observations were made by one person.

This census method now has been experimented with for one year. It gives promise and is described in the hope that those interested in pheasant tabulation in other states will try it and record their findings. The observer drives through any area to be censused from dawn until an hour after sunrise. At intervals of five miles a bomb is shot and the pheasants responding are counted. Even with the present driving restrictions, a much greater area can be censused than by the roadside count which covers only 15 to 30 miles.

Detonation tests were conducted in 10 counties at different periods of the year; pheasant responses, by months, are shown in Table 1. It is evident that pheasants respond most readily to explosions during the early months of the year, before and during the breeding season when they are normally crowing. Response was least during August when natural crowing ceased and the males were molting.

During the hours in which observations were made, the most consistent response was in the early morning. The high, between 5 and 6 p.m. (Table 2), is probably the result of insufficient data, but there is a regular drop in response from 6 to 10 a.m. and from 6 to 9 p.m.

TABLE 2.—RESPONSE OF PHEASANTS TO BOMBS AT DIFFERENT HOURS

Time of day	*Number of shots*	*Average responses per shot*
6–7 A.M.	19	12.0
7–8	54	11.1
8–9	39	8.4
9–10	29	6.6
4–5 P.M.	5	1.2
5–6	9	28.2
6–7	25	10.0
7–8	20	8.9
8–9	46	5.0
Total	246	10.1

There does not seem to be any important effect of temperature upon the responses. The optimum range (Table 3) appears to be between freezing and 50°F., which is the usual early morning range of temperature during the spring. The high response from zero to 10°F. results from insufficient data. This method can be used, however, when

temperatures are below freezing, with a good response by the birds.

There is no conspicuous relation between the response of the birds and types of weather (Table 4). On clear humid mornings sounds travel longer distances and reverberate from hills and objects so that there is an excellent response. In cloudy weather it is much the same, except that the sound of the explosion reverberates from the clouds and stimulates an equally good pheasant response. As already indicated, wind greater than five miles per hour nullifies the success of the method.

TABLE 3.—RESPONSE OF PHEASANTS TO BOMBS AT DIFFERENT TEMPERATURES

Air Temperature	*Number of shots*	*Average responses per shot*
0– 9° F.	4	36.2
10–19°	8	4.5
20–29°	30	10.3
30–39°	27	27.1
40–49°	35	15.3
50–59°	19	7.1
60–69°	76	7.1
70–79°	37	2.4
80–89°	10	4.3
90–100°	0	

Except in May, the number of pheasants calling during one minute was counted at each stop made to fire a bomb. The greatest normal volume of crowing was during April, with a steady trend downward to cessation of crowing in August. In March the response to bombs was greater than the number of birds heard crowing in one minute. In April (data incomplete) the number of birds crowing spontaneously was greater than in response to explosions. In June it was also greater, but was less in July than the response to bombs. In all probability, the use of the one minute count at each stop is as effective, if not more effective, than the use of the bomb as a method of estimating populations for the pre-breeding and breeding periods. For the remaining eight months of the year the detonation method continues to be effective. It is

TABLE 4.—RESPONSE OF PHEASANTS TO BOMBS IN DIFFERENT KINDS OF WEATHER

Weather	*Number of shots*	*Average responses to bombs*
Clear	100	11.4
Partly cloudy	97	9.3
Cloudy	45	11.4
Total	242	10.7

believed that if the present studies can be continued for a two or three year period so that we have an average monthly response, it will be possible to determine factors which will give us a reliable estimate of the pheasant population.

The detonation method gives a consistently better population estimate in the summer and autumn, as compared with roadside counts. Then only one or two birds per mile may be seen during a 15 or 30 mile trip, but many more will respond to the explosions, indicating a denser population than the roadside counts would reveal. This, too, needs further examination.

As yet, we have no correlation between the numbers of pheasants crowing in response to a bomb and the actual number of males present on a given piece of land. Preliminary attempts to derive this information are shown in Table 5. On the W. E. Dunne ranch in Loup County, within the Nebraska sandhills and along the Calamus River, two sections of land were covered once a week in an effort to count all pheasants present. During these observations in the summer and autumn of 1942, when the air was calm at sundown,

TABLE 5.—RESULTS OF DETONATION TESTS WITH PHEASANTS ON W. E. DUNNE RANCH, LOUP COUNTY, NEBRASKA

Date (1942)	6/4	6/11	6/18	6/25	7/2	8/5	8/13	8/30	10/1	10/8	10/29	11/12
Bombs exploded	4	4	4	4	4	4	4	4	4	4	4	4
Total calls	17	19	10	22	17	1	1	1	13	4	2	16
Average calls per shot	4.2	4.8	2.5	5.5	4.2	1.7	.2	.2	3.2	1	.5	4
Total calls in 5-minute counts	46	61	41	103	105	1	0	1	6	—	—	—
Average calls per 5 minutes ÷ 2	7.5	7.5	5.0	12.8	13.1	—	—	—	3	—	—	—
Average calls per minute	3	3	2	5.1	5.2	.05	—	.05	—	—	—	—
Birds responding more than once	4	5	2	6	4	—	—	—	3	—	—	2
Birds responding to all shots	1	1	0	0	1	1	—	—	2	—	—	2
Total birds heard	9	12	6	14	18	4	1	1	7	3	2	12
Percentage of birds calling per shot	*46*	*40*	*41*	*40*	*23*	*42*	*100*	*100*	*46*	*33*	*50*	*33*
Percentage of birds calling in 1 minute	*33*	*25*	*33*	*37*	*30*	—	—	—	—	—	—	—
Percentage of birds calling in 5 minutes	*83*	*62*	*83*	*91*	*73*	—	—	—	*43*	—	—	—
Total males counted in section	7	5	5	8	7	3	0	2	27	49	52	71
Percentage of birds heard to birds seen	*1 0*	*240*	*120*	*175*	*260*	*130*	*100*	*50*	*26*	*6*	*4*	*17*

four bombs were shot at five-minute intervals. In the 20 minutes needed for the test, the total number of pheasants calling were recorded. From this we had the average number of responses to each bomb and the total calls in each five-minute period. Since the average pheasant crows twice in five minutes, dividing this figure by two would indicate the number of birds calling. When feeding of an evening, a pheasant usually moves only a matter of a few yards in twenty minutes. By spotting on a map the position of each bird as it called, it was possible to determine which ones were responding to more than one bomb. Over the 20-minute period, through the use of this map, all of the birds calling could be spotted. During June and July it seemed that the number of birds calling at each shot was consistently over 40 per cent of the total calling in 20 minutes, whereas the number calling in one minute was approximately one third of those calling in 20 minutes. Furthermore, the number crowing in five minutes was consistently more than 60 per cent of the total. Thus there are three possibilities: (1) a one-minute count may yield one third of the birds in a vicinity; (2) use of the bomb causes nearly 50 per cent to crow; and (3) by counting the birds for five minutes nearly three-fourths of the male population is heard. The factor still unknown is the percentage of males not crowing. Because of the adroitness of these birds at hiding, even a thorough traverse of the land would not show as many in the area over which crowing counts were made as the number of birds heard calling would indicate as present. These variables are included in Table 5.

The data obtained are presented at face value, realizing that the method has not been tested adequately or over a period of sufficient length. The results given in the tables obviously may change as more material is accumulated. The method is spectacular and has the advantage of capturing the layman's imagination. It shows promise as compared with other methods of pheasants censusing, and when restrictions on the use of fireworks have been lifted, should be worth attempting in various states where the pheasant is important as a game bird.

SUMMARY

Pheasant populations may be estimated or densities indicated by stimulating the males to crow in response to the explosion of small aerial bombs. The males respond at all seasons, but in greatest numbers in the spring. Response is greatest in early hours of morning and evening. Optimum temperatures appear to be between freezing and 50°F. Weather has little effect except that the method is not practicable during wind greater than five miles per hour.

COMPARISON OF COYOTE TRAPPING METHODS

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In a study of coyote-cattle relationships on the San Carlos Indian Reservation, Arizona, the writers and others compared, by field tests, the chain-noose trap and standard steel-jaw trap to learn which type was more humane, practical, and efficient in capturing coyotes. The tests were conducted between April 23 and May 12, 1941, on Ash Flat and adjacent territory within the Reservation, at altitudes of 4,500 to 5,000 feet. Most of the trapping was done by the senior author; the junior author assisted in trapping and prepared the report. Assistance and advice on various details were given by Vernon Bailey, Harold J. Rush, and Harry P. Williams. The experiment was conducted as a research project of the U.S. Fish and Wildlife Service at the request of the Office of Indian Affairs.

Forty-four trap sets were made, 22 each with chain-noose traps and steel-jaw traps; the two kinds were paired and set in as nearly identical positions as possible. For example, on a trail crossing a wash, a steel-jaw trap was set on one side of the wash and a chain-noose trap on the other. The number of sets per day varied from 10 to 32; the total trap nights were 174. Baiting was entirely with scent, both natural and fetid, at random on pairs of sets. The traps were Verbail No. 2, the largest of the only chain-noose type commercially available, and the Newhouse No. 14. A steel trap with offset jaws, such as the 3N Victor, would have been preferable, but was not then available. The chain-noose traps were set in the manner recommended by the inventor. Sets were made only in places known to be frequented by coyotes along a route of about 26 miles. Most of the line had been investigated thoroughly for coyote sign during one to four weeks preceding

the trapping. Such investigation obviously made the coyotes more wary and difficult to catch, but the trapping experiment was incidental to the primary study of coyote-cattle relations, which had to be done before the population ratio had been disturbed by trapping. Each set was kept in place for 2 to 6 nights, depending on circumstances, and with two exceptions all were visited daily. Photographs of trapped animals were taken and captured animals were dissected where necessary to reveal the extent of injuries.

TABLE 1.—SUMMARY OF TRAPPING EXPERIMENTS

	Steel-jaw traps	*Chain-noose traps*
Coyotes caught and held	9	—
Coyotes caught but escaped	—	2
Sprung or uncovered by coyotes	—	8
Total visits by coyotes	9	10
Other wild creatures caught and held	4	1
Sprung by other wild creatures	1	—
Sprung or uncovered by domestic stock	10	16
Sprung by drag of another trap	1	—
Sprung or uncovered; cause unknown	2	1
Total disturbances	18	18
Not visited or disturbed	60	59
Total trap nights	87	87

In the following account of results the sets designated by number only were of steel-jaw traps, and with corresponding numbers followed by the letter "a" were of chain-noose traps, indicating the pairs of sets. Chain-noose numbers followed by "A" indicate that the trap was secured to a specially designed iron anchor recommended by the inventor; "D" indicates use of a conventional chain and drag. All steel-jaw traps had drags. Sets 1, 1aA, 2 and 2aA were taken up between April 24 and May 7 to avoid interference with necessary ecological studies. Sets 5 and 5aA could not be visited the first day because darkness overtook us before reaching them. Certain sets were taken up before termination of the experiment for various reasons: disturbance by cattle or ravens; lack of fresh coyote sign; and evidence that the pair frequenting an area had been caught, become trapwise, or changed its accustomed route of travel. All sets remaining on May 12 were removed on that day.

Pertinent facts relative to the 16 catches made were as follows:

Coyote A. Female. Caught April 23 in set No. 1aA which was out 1 night. Tracks indicated that the coyote had quickly pulled up the anchor and escaped. The faint trail was lost after being traced for about 100 yards. On May 7 the same coyote was seen and shot about 1½ miles west of the set. The trap was still attached to its right front foot, but the anchor and setting hook were missing. The chain-noose was nearly severed in one place, apparently by biting. The chain had completely sawed through all skin, flesh and tendons, leaving the leg bones exposed for about 1½ inches. There was evidence of bleeding and the flesh of the foot was beginning to decay. The animal was extremely emaciated, and was or had recently been suckling pups (uterine evidence of 4); there was little but rocks in its stomach.

Coyote B. Male. Caught April 24 in set No. 1, which had been out 2 nights without other results. Caught by the right front foot; no broken bones or skin abrasions; one trap-tooth puncture through flesh of foot; slight bleeding.

Coyote C. Male. Caught April 24 in

set No. 2, out 2 nights (caught Fox "A" the first night). Caught by the right front foot; no broken bones or skin abrasions; trap-tooth puncture through flesh; slight bleeding.

Coyote D. Male. Caught May 7 in set No. 8, out one night. Caught by the left front foot; no broken bones or skin abrasions; trap-tooth puncture through flesh; slight bleeding.

Coyote E. Caught May 8 in set No. 15aA, out one night. Tracks indicated it had escaped quickly with slight struggle. The chain was severed in one place, and nearly severed in another, apparently by biting, but the anchor was secure. No blood stains on trap or ground.

Coyote F. Young female. Caught May 10 in set No. 14, out three nights (sprung 2d night by unknown cause). Caught by right front foot; no broken bones; skin and flesh worn to the bone in one place about $\frac{5}{8}$ inch in diameter; trap-tooth puncture through flesh; moderate bleeding. Tracks indicated that the trapped animal had been harassed by several cows and had struggled violently when the drag became entangled in brush.

Coyote G. Male. Caught May 11 in set No. 19, out 2 nights without previous results. Caught by right front foot; no broken bones; skin and flesh worn to the bone in one place about $\frac{1}{2}$ inch in diameter; trap-tooth puncture through flesh; moderate bleeding.

Coyote H. Young female. Caught May 11 in set No. 7, out five nights without previous results. Caught by the right front foot; no broken bones or skin abrasions; trap-tooth puncture through flesh; slight bleeding.

Coyote I. Male. Caught May 11 in set No. 12, out five nights, and sprung on three of those nights, twice by cattle and once by an unknown cause. Caught by right front foot; no broken bones; skin and flesh worn to the bones in two places, each about $\frac{3}{8}$ inch across; trap-tooth puncture through flesh; moderate bleeding.

Coyote J. Male. Caught May 12 in set No. 19, in which Coyote "G" had been caught the previous night. Caught by the left front foot; no broken bones; skin abraded in two places, each about $\frac{5}{8}$ inch in diameter and exposing about one fourth that area of bone; trap-tooth puncture through flesh; considerable bleeding. Evidence indicated coyote had been caught the previous evening and had struggled violently much of the night. The drag, chain, trap, and coyote were entangled in a cat-claw bush that had been reduced to a few stubs, $\frac{1}{2}$ inch in diameter or larger.

Coyote K. Male. Caught May 12 in set No. 21, out two nights without previous results. Caught by the right front foot; no broken bones or skin abrasions; trap-tooth puncture through flesh; very slight bleeding.

Fox A. Caught April 23 in set No. 2, out one night. Released alive, sex not determined. Left front leg somewhat skinned but apparently not severely; moderate bleeding

Rabbit A. Caught April 23 or 24 in set No. 5aA, out two nights. Caught by left front foot, which was all but severed by the sawing of the chain (only the tendons intact); large skinned areas on both front and hind legs, apparently from the chain and abraded by violent contact with the ground while struggling.

Ravens A, B and C. All caught in

steel-jaw sets; one leg slightly skinned in each, dislocated in "C."

DISCUSSION

From the tabulated results it would appear that an amazing degree of skill had been exercised in making sets so nearly identical as to produce an almost equal number of coyote visits and other disturbances to the two types of traps. The equality is more apparent than real. Of the ten trap nights when chain-noose traps were visited by coyotes, three were plain cases of coyote suspicion caused by improperly made sets. The junior author was chagrined that he made these sets with false confidence inspired by several other sets that had fooled coyotes on previous nights. As nearly as we could read the tracks and signs, all the other instances of chain-noose traps being uncovered or sprung by coyotes without catching anything were due to the construction of the trap.

The proportionately large number of chain-noose traps sprung or uncovered by domestic stock was also traceable to the same cause. Two mechanical deficiencies were apparent: the pan could not be adjusted to a constant and delicate tripping point; and the trap, when set as recommended, was too close to the surface of the ground. The entire trap is at the same horizontal level as the pan; hence the foot of an animal, when pressing on any portion, can easily tip the light-weight trap up out of the soil. An equal foot pressure on a steel-jaw trap, which is comparatively heavy and deeply embedded, will seldom disturb it unless the pan is pressed down. This was proved in several instances when cows, calves, and coyotes stepped on both chain-noose and steel-jaw traps without pressing upon the pans. Among the steel-jaw sets, there was one case in which the trap was uncovered and unsprung, and four in which a foot print was easily refilled with dirt, causing so little disturbance as to warrant listing as "blank." Among the chain-noose sets there were five traps uncovered and unsprung (excluding the three intentionally done by coyotes), and one that was easily smoothed over and listed as "blank." We made a few trial sets on which the properly weighted foot-falls of a coyote were simulated with sticks or fingers, avoiding the pan, and found that the chain-noose traps often were exposed by such action but the steel-jaw traps were not. Finally, we attempted to make deeply embedded chain-noose sets but the spring, spreading horizontally in a wide arc, could only function properly in a hole so large as to make concealment difficult.

Since the chain-noose traps in this experiment were accidentally exposed by coyotes with relative ease and were often sprung without holding or catching the animals, it would seem that continued use would result in a large proportion of escaped, trap-wise coyotes, but this test did not continue long enough to afford conclusive evidence. Two pairs (8 and 8aA, 11 and 11aD) proved ineffective after the chain-noose types had been sprung by coyotes, but with another pair (12 and 12aA) a coyote was caught after the chain-noose trap had been incompletely sprung by a coyote. This pair was set in one of the few places which we knew positively to be frequented by more than one pair of coyotes.

The frequency of disturbance by

domestic stock may have affected the accuracy of the experiment. In several cases cow tracks were so numerous that it was impossible to determine whether other animals had previously sprung the traps. We learned from cowboys that most of these were due to cattle being unintentionally driven over the traps soon after the latter were set. Thus, on May 10 our inspection included eight traps (2, 2a and 11 to 13aA) along a certain road; a few hours later a herd of cattle was driven past, and the next day six of the traps were found to be uncovered or sprung.

Chain-noose traps usually were placed in "surface" sets and steel-jaw traps were embedded deeply, but there was no appreciable difference in the time required for setting. The time saved by not having to dig for a chain-noose set was invariably lost in adjusting the trap. Even in the infrequent cases where the pans did not require readjusting, the springs needed tightening. They did not retain full tension after being compressed for twenty-four hours or more. The only exception to this was a trap which the inventor supplied from his personal stock.

Weather and soil conditions were ideal; there was no frost or rain when the sets were out, and there was just enough moisture in the soil to facilitate easy setting. Trouble was often encountered in finding suitable locations reasonably free from rocks or brush that would interfere with the chain-noose sets. Clearing enough ground to permit free horizontal expansion of the spring was impractical because of the difficulty of successfully hiding evidences of the set.

The chain-noose traps are much lighter in weight than the steel-jaw traps, an important factor to any trapper, but tests showed that they are too light to hold a coyote properly. As no larger size was available, the test was not an equal comparison in this respect. The size could be considerably greater without equalling the weight of the steel-jaw traps. The saving in weight, however, is somewhat nullified by inconvenience, as the pans of the chain-noose traps are not attached and are easily lost. Some time was wasted in returning to camp to replace lost pans.

From the meager showing made by chain-noose traps in this experiment, they appear to be more inhumane than steel-jaw traps. Lacking material for direct comparison, several inferences can be drawn from past experiences of the senior author with steel-jaw traps. Had Rabbit "A" been caught in a steel-jaw trap, the leg might have been punctured by a trap tooth to produce a mutilation as severe as that actually inflicted by the chain-noose, or it might have been caught between the offset jaws and been pulled entirely free without injury. Occasional breaks occur merely from the impact of the trap jaw before it fully closes, but if the rabbit's leg is vertical and centered it can usually be pulled free without injury, especially in a trap with offset jaws but no teeth. Had Coyote "A" been caught in a steel-jaw trap, its escape and consequent suffering would have been improbable. About one per cent of the many coyotes taken by the senior author in steel-jaw traps of the kind used in this experiment have succeeded in escaping. Such escapes have nearly always been by twisting or biting off the foot, resulting in a "peg-leg" that

soon heals and seldom critically hampers future hunting for food. It is rare that a coyote will break the drag chain and carry a steel-jaw trap on its foot while slowly starving to death or waiting for the foot to slough off as did Coyote "A" with a chain-noose trap.

That is as far as inferences can be carried safely. No evidence was obtained to show what the chain of a chain-noose trap would do to a coyote's foot if the animal were entangled in a bush as was Coyote "J"; Coyote "A," however, furnished a somewhat parallel example of the sawing action of the chain.

The subject of humane trapping methods might easily be extended into an academic discussion of the ethics of trapping, beyond the province of this report. It is pertinent to emphasize, however, that the livelihood of many people is directly dependent upon the efficiency of the traps they use in securing furs, and the livelihood of many more is indirectly affected by the efficiency of the methods used in controlling certain animals that otherwise would interfere with or even prevent profitable livestock production and certain other land uses. The primary purpose of an animal trap is to catch and hold animals in an efficient and practical manner. This should be done as humanely as possible without raising the cost of trapping to a point where the legitimate and proper management of fur resources and predators becomes impracticable.

SUMMARY

A field test of trapping methods was made on the San Carlos Indian Reservation, Arizona, in the spring of 1941, to compare the relative merits of chain-noose traps and steel-jaw traps for coyotes. The chain-noose traps were decidedly less efficient and less practical than the steel-jaw traps, and apparently somewhat less humane.

Steel-jaw traps and chain-noose traps were set under closely similar conditions, resulting in 9 coyotes caught and held by the former during 87 trap nights; and 2 coyotes caught but none held by the latter during the same number of trap nights.

The relative inefficiency of the chain-noose traps was found to be due chiefly to the arrangement of the tripping mechanism and the spring.

Although a comparison of humane qualities was difficult, owing to the small number of trapped animals in this test, the sawing action of the chain-noose trap produced more severe injuries than any by the steel-jaw trap.

HABITS AND ECONOMICS OF THE NEW YORK WEASEL IN MICHIGAN

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During the autumn, winter and spring of 1939 and 1940, the habits and economics of the New York weasel (*Mustela frenata noveboracensis*) were studied in Lodi Township, Washtenaw County, near Ann Arbor, Michigan. The area is typical southern Michigan glaciated farm country, with a dispersion of bogs and kettle holes on ground morainal deposits. The cover consisted of interspersed agricultural, woodland, and marsh types in a ratio of about 70, 15 and 15 per cent, respectively.

Wildlife Relationships to the Farm

Because of its economic status in relation to the farm, the weasel's poultry killing habit was studied by directly interviewing all the local farmers. The data cover the year preceding the investigation, October 1938 to October 1939, and consist of occurrence records of wildlife on barn areas (immediate surroundings of the farm buildings exclusive of fields and woodlots), wildlife killed in barn yards, trapping records, poultry losses by predation, poultry populations, and barn area environs. All mammalian and avian forms were considered to compare their effects on farm economics. The accuracy of this phase of the study is subject to the veracity of the farmers who reported the information presented, and to their ability to identify properly the predators involved in poultry losses.

Analysis of the data (Table 1) showed that weasels inflicted greater poultry losses than any other predator. Barn rats (*Rattus norvegicus*) caused the greatest loss of ducks, having killed 100 young on one farm. Since this high incidence occurred but once, it prohibits a conclusion that rats are consistently more destructive to ducks than are other predators. Farmers reported chicken houses invaded by raccoons and skunks but were unable to give conclusive loss data. The latter animals usually were intercepted by dogs before doing any damage, but they constitute a potential loss factor. Opossums, also, were usually caught before damage was inflicted, but in two instances caused poultry losses; the two opossums were killed in chicken yards. No predation by birds was reported.

Table 1.—Poultry Losses by Causes in Percentage of Total Poultry on Farms

	Total on farms	*Killed by*					*Total number killed*	*Percentage killed*
		Weasel	*Mink*	*Opossum*	*Rat*	*Fox*		
Chickens	17,555	*1.03*	*0.12*	*0.03*	*0.6*	—	301	*1.7*
Ducks	240	*4.2*	0.4	—	*41.6*	—	111	*46.2*
Turkeys	80	*50.0*	—	—	—	*31.2*	65	*81.2*
Geese	59	—	—	—	—	—	0	—
Guinea hen	—	1 only						

TABLE 2.—PERCENTAGE OF TOTAL KILL BY EACH KIND OF PREDATOR

	Total killed	*Weasel*	*Mink*	*Opossum*	*Rat*	*Fox*
Chickens	301	*59.8*	*6.6*	*1.0*	*32.6*	—
Ducks	111	*9.0*	*0.9*	—	*90.1*	—
Turkeys	65	*61.2*	—	—	—	*38.8*
Guinea hens	1	100.0	—	—	—	—

The proportion of damages inflicted by the several mammals are listed in Table 2. The weasel caused nearly 60 per cent of the total loss of 301 chickens on the township, and rats over 32 per cent. The total number of kills made by wildlife (301 chickens, 111 ducks, 65 turkeys) represents a loss of several hundred dollars to the farmers of this one township. It cannot be evaluated exactly because of the potential value of egg production lost when the chickens, ducks, and turkeys were killed, and also because of variations in market quotations for poultry, since the kills were made during a period of one year. The methods by which the predators were killed are summarized in Table 3. Apparently more were shot than were killed by farm dogs and cats.

Weasels were seen on about 19 per cent of the farms and of the total number seen, about 68 per cent were killed. It is of interest that this degree of control exists in one small part of a state where no bounty has ever been offered as an incentive to control. Farmers naturally attempt to protect their livelihood from predators regardless of such an inducement.

The occurrence of weasels around the barns often was coincident with the presence of rats, which in turn was correlated with such environs as nearby garbage dumps, poorly stored grain, and ill-kept chicken houses. Substantial and well kept housing would help to exclude both disease and predation.

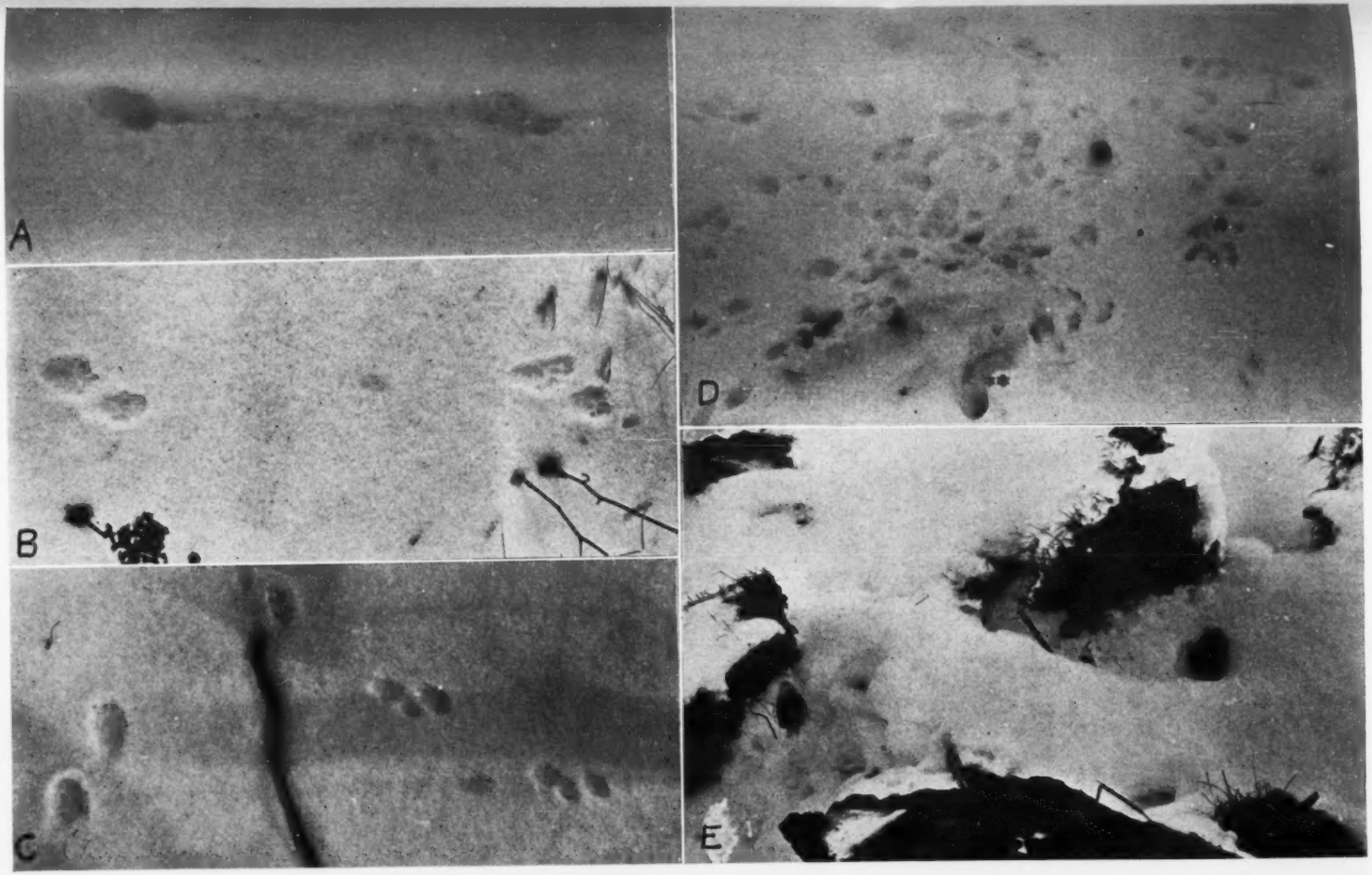
About 65 per cent of the visits by weasels to barn areas were made between April and August, and the remainder from August until late November; none was reported from December until April. These data suggest that barn areas were attractive to weasels when the adult females were feeding new litters and in need of abundant and easy prey. (Unfortunately, no data were available as to the sex of weasels taken on the barn areas.) This also is the time when farmers are rearing young chicks. The weasels evidently

TABLE 3.—OCCURRENCE OF WEASELS IN BARN YARDS

Month	*Trapped*	*Shot*	*Seen and killed*		*Beaten*	*Seen but escaped*
			by dog	*by cat*		
April	—	2	—	—	1	1
May	—	1	1	—	—	—
June	1	2	—	—	—	2
July	2	—	2	—	—	1
August	1	—	1	1	1	2
September	1	1	—	—	1	—
October	—	1	—	—	—	2
November	—	—	—	1	2	3
Percentage killed of all seen	*14.7*	*20.6*	*11.7*	*5.9*	*14.7*	

Aggregate killed of total seen *67.7%*

December to March, no record



Weasel tracks and tunnels. *A*. Tracks in deep wet snow, with drag marks. *B*. Tracks of same weasel in shallow dry snow; hind foot steps in track of front foot. Animal travelling from left to right. *C*. Tracks of large male showing toe marks (*left*), and of female with irregular placement of feet (at right). *D*. Tunnels and maze of tracks on 4 inches of snow over cornfield; tunnel exit in center foreground, **. *E*. Tunnels in snow under furrows in plowed ground. Photos by Doris and H. F. Quick, February, 1940.

moved to strictly wild environs as winter approached.

The fur of some predatory mammals has a value tending to offset the cost of damage inflicted, but the trappers of Lodi Township received little from weasel hides; most of them do not consider the pelts worth handling for the small sums they would bring. One trapper reported selling two weasel skins for a total of $1.20.

WINTER HABITS

Little information on winter habits was obtained until snow facilitated tracking. With the first fall of snow an area was cruised at random to search for weasel trails. After several weeks of tracking it was found that four individual weasels occupied a certain square mile of land (Sec. 3, Lodi Township). Intensive study of habits was limited to this section and small bordering areas. Cover maps (Wight, N. Amer. Game Conf. Trans., 20: 329–333, 1934) then were made on a scale convenient for plotting the weasel trails. These were mapped by reference to surface features while tracking. A separate map was used each day. Where tracks of some other mammal or a bird intersected a weasel trail these were added and notes were kept on the activities of all wild life observed to give a correlated picture of interspecific relationships.

Occasionally, because of poor snow conditions, continuous tracking was impossible. After becoming familiar with the favorite haunts of the animals under observation, it then was possible to visit such places and search for a fresh track on a patch of snow. By plotting these single tracks or short lengths of trail and noting the direction of travel, a probable course later could be mapped; this gave, at least, an index to minimum cruising radius.

In all, 52 trails by four weasels were mapped on 38 days suitable for tracking between January 6 and April 12. These track maps showed that the animals traveled approximately 53 per cent of the time over crop and fallow land, 29 per cent over plowed ground, and

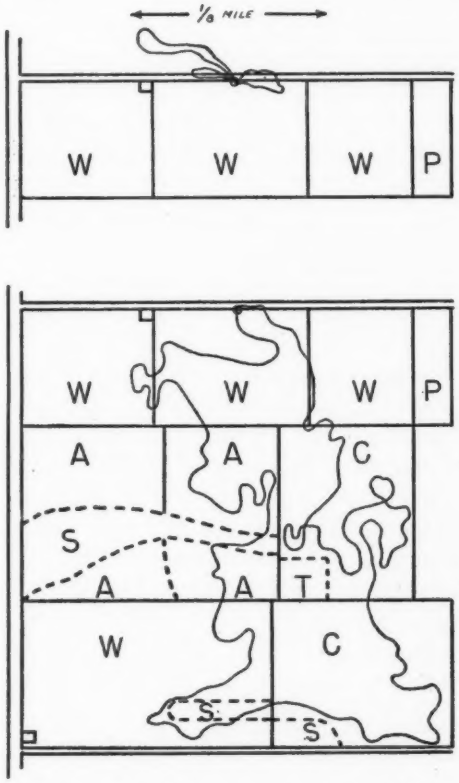


FIG. 1. Sample track maps of weasel No. 1 on part of Sec. 3, Lodi Township, Washtenaw County, Michigan. *Above*, smallest range (Jan. 24); *below*, largest range (Jan. 7).

Road at left; lanes paralleling fields; land above lane at top was plowed; irregular solid line, weasel trail; ○, den; ———, fence; – – – –, cover type line (unfenced); *A*, fallow weed pasture; *C*, shocked corn; *P*, pasture; *S*, slough grass; *T*, wood lot; *W*, wheat stubble.

18 per cent through wooded lands. Stubble and plowed fields seemed to be preferred as hunting grounds.

TRAILS

Weasel trails characteristically meander, but straight courses of a quarter mile or more occasionally were found, usually along a fence row or ditch which might seem to hold the interest of a weasel. Even there, however, it was common to find the trail passing under the fence or across the ditch at frequent intervals. Where signs of prey are found in snow, mazes in the trails are typical; at such places weasels usually travel in overlapping loops and circles, occasionally digging into mouse burrows to search for food.

The individual trail generally is marked as a series of bounds indicating a loping gait. Of all trails followed, less than a total of 50 yards revealed a walking gait, and these were near the tracks of mice suggesting that the weasel slackened its speed for stalking.

A live male weasel was released and recaptured twice, by running it down in an effort to learn its speed of travel. The weasel dodged erractically, was difficult to grasp, but not difficult to overtake. The bounds were not as long as the average of those measured in the undisturbed conditions of normal travel. Under the pressure of pursuit, the animal evidently shortened the length of bound to facilitate maneuvering, and seemed to rely on shiftiness rather than speed for escape.

Efforts were made to obtain qualitative data on track measurements as a means of distinguishing the sexes and censusing weasels, after the method used by Marshall, on mink (Journ. Mammology, 17: 382, 1936). Favorable conditions occasionally permitted accurate measurements of hind foot tracks, but so rarely that it was deemed impractical to depend on this method.

Later the "width of straddle" was used to distinguish tracks of males and females. This is the greatest distance across the tracks measured at right angles to the line of travel and gives an index to the size of the animal that made the tracks. The track of any individual varies according to surface conditions (Pl. 4, A, B), but in a given locality on a particular date, conditions would be sufficiently uniform to permit use of this method to distinguish tracks of male and female weasels and of mink. The method gave promise but not enough individuals were present to check it thoroughly. W. H. Burt suggested that large samples would be needed and caution should be exercised to avoid confusing immature males with adult females.

INTRASPECIFIC RELATIONSHIPS

Collectively, the home ranges of the four weasels studied covered a little over 640 acres. Occasionally two of them (nos. 1, 2) left the section on which their dens were located. Another (no. 3) denned on this section within ten chains of its border and once crossed through a road culvert to hunt in a cornfield in the adjacent section to the north. The fourth weasel denned on the section to the south, but hunted mostly on that occupied by the other three.

In calculating the home range the maximum radius of action from the den (as shown by track maps) was used to define a circular tract representing the area an individual was apt to cruise. The maximum radii were as follows:

no. 1, 0.45 mile; no. 2, 0.41 mile; no. 3, 0.20 mile; and no. 4, 0.375 mile. These represent circular tracts of 80 to 400 acres, presumably the home ranges of the weasels. All individuals studied tended to travel similar distances daily; however, no. 3 traveled less in the aggregate than the others.

Although the calculated range of each was nearly 400 acres, and the ranges overlapped (because the four were on one section) they rarely crossed trails on the same day. An exception occurred February 29, when the tracks of no. 4 (believed to be a female) intersected those of a large weasel (known to be a male). The trails met at a post on a fence corner; it appeared that both had voided urine and feces and then gone their separate ways. Similarly on March 28, the trails of these same weasels met at the same post, then led along the fence for about 18 chains and both entered the den of the male (which had been live-trapped, sexed, and measured previously). Only the tracks of the smaller weasel left the den on the same date. Observation on April 12 showed that the large male still occupied the den.

These violations of home range habits might be considered as a demonstration of expanded range during the breeding season. Because of melting snow it was impossible to obtain further data on the movements of these weasels.

DISTANCE TRAVELED

Daily travel distances were calculated by applying spacing dividers to the plotted trails recorded on the track maps. The average from 52 maps was 101.7 chains or 1.27 miles. The minimum travel in a single night was less than one chain, and the maximum was 275 chains or 3.43 miles, both registered by the large male whose mean daily travel distance was 160 chains or 2 miles.

TRAVEL HABITS

Weasels traveled on the coldest night of the year (−5°F.), but they did not travel every night; occasionally they seemed to remain in their dens for 36 to 48 hours.

RELATIONS WITH OTHER SPECIES

Field notes and track maps on the movements of weasels and other animals were used to study interspecific relationships. Tracks of raccoons, opossums and skunks occasionally crossed weasel trails, but apparently they were tolerated by the weasels and the weasels by them. Trails of red squirrel and opossum led to within 12 inches of occupied weasel dens, but evidenced no regard for the "ferocious" predators. Hair of the red squirrel, however, was found in several weasel feces. A mink occasionally hunted over part of the study area, especially along a drainage ditch and an adjacent slough. At times Weasel no. 2 also hunted here, but never on the same night as the mink.

Rabbits were observed all winter on the study area; one lived under a hay stack, but no evidence of attack on the rabbit was ever found. Ten rabbits were known to have started the winter on the area. One was killed in a steel trap, another by a mink, and a third by some bird of prey. The remaining seven survived the winter safely as proved on late tracking snows.

There was no indication that the weasels made any attempts to kill rabbits. Since the study was completed, the writer saw a captive weasel kill a nearly full grown rabbit, but he believes that

in the wild the kill would never have been completed because the frightened leaping of the rabbit threw the weasel off several times. It is known that weasels kill rabbits, but dozens of attacks must occur to effect even one kill. Murie (Univ. Mich. Mus. Zool. Misc. Publ. 32, 1936) has reported the failure of weasel attacks on rabbits.

During the autumn and winter, a covey of 10 quail ranged on the study area. It changed roosting grounds several times during the season, and once roosted in a kettle thicket about 50 yards from the den of a large male weasel. Trails of this weasel led through the roosting place but no kills were found here. The quail evidently had left before the arrival of the predator, or had been flushed by his approach. No trace of quail was found in feces collected from this weasel. When the covey moved in midwinter to a nearby woodlot, it roosted on the southern slope of a small borrow pit. The birds occasionally entered the mouth of an enlarged abandoned den in the bank of the pit, and it was anticipated that one would eventually be caught there by some predator. One morning quail feathers were found at the entrance; and weasel tracks in the snow around the den were followed to a den. By reaching to arm's length into this den, a handful of quail feathers was retrieved and analysis of scats taken there showed that a quail had been eaten.

Ringnecked pheasants were present on the study area, but only one winter kill was found, made by a mink. The writer does not believe that the weasels harassed the pheasants.

Mice and a few song birds constituted the prey of the weasels studied, except for the one quail mentioned.

In the early spring the remains of a song sparrow (*Melospiza melodia*) were found on a weasel trail. The bird apparently had been killed by the weasel and the flesh eaten on the spot; the bill, wings, feet and legs, ribs, and backbone were left with the feathers. The trails of weasels showed that they sometimes climbed low bushes and trees, probably in search of roosting song birds. In total, only one junco (*Junco hyemalis*) and the song sparrow were found on such trails.

Evidence of the killing of only one mouse (*Peromyscus*) was seen, where blood and a few hairs were found at the end of its trail on the snow. Apparently it was consumed where the kill was made.

Most mouse prey probably is caught below the surface of the snow as indicated by the drag marks of mouse tails along weasel trails leading from subnivean tunnels to dens. The weasels probably cached mice elsewhere but seemed to carry them to the den if not eaten where caught. More recent observation of caged animals show that a weasel when hungry, will eat a mouse entirely, or occasionally leave only small shreds of skin and fur.

HABITS

A popular characteristic of weasels is their curiosity, and this is disclosed by following their trails. Scarcely a hole or a den is passed by a weasel without being investigated. The writer believes that this may be the basis for the belief that a weasel uses several dens. The results of the winter's tracking study prompts a conclusion that one den per animal is the more common arrange-

ment. The weasels appeared to prefer hunting certain coverts with noticeable regularity, but rarely cruised the same area on two consecutive nights.

The habit of defecating at a particular spot, or "latrine," is common to both the weasel and mink. Since trails in the snow were easily followed, the habits of these animals were observed conveniently in such matters. The latrines of weasels were in the entries of used dens and scats could be collected there by the handful. Mink latrines (over 300 scats in one) were found at concealed niches along favorite travel routes. The scats of weasels and mink also were found, sparingly, at random along their trails. As many as five weasel scats were found on one rock, each apparently deposited on a separate visit. Places were found occasionally where the animals had urinated. On the snow these appeared greenish, but any odor seemed lost because of the cold. No special scent post habit was noted, the animals appearing to have urinated at the most convenient time and place.

WINTER FOOD

The "latrines" contained somewhat variable quantities of scats. Den no. 1 yielded 215 scats, totaling (air dry weight) 35.52 grams; Den no. 2, 240, weighing 29.47 grams; and Den no. 3, 44, weighing 4.01 grams. Some additional scats were collected at random along trails.

A total of 534 scats was collected, representing the four weasels. Of these, 294 were examined individually with a binocular dissecting microscope. The remaining 240 were analyzed experimentally in bulk; Table 4 indicates results by frequency of occurrence.

The five items listed were not identified to species because of the altered condition of the material after having passed through the digestive systems of the weasels. Feathers of juncos, song sparrows, and a quail, however, found in the dens and on trails, together with the presence of these birds on the study area, were strong clues suggesting that these small birds were taken more frequently than others. Twenty of the scats examined were composed entirely of feathers and tiny bone fragments, likely the remains of the birds mentioned.

The occurrence of mice in the diet was determined by the presence of teeth, bone fragments, and hair washed from the scats. Red squirrel hair found in three scats collected along trails, suggesting that it is not unusual for weasels to take this species. Since these scats were found on the snow it is probable that the squirrels were full grown when taken.

Weasel hair appeared a number of times in the analyses but this is not

TABLE 4.—ANALYSES OF WEASEL SCATS

Source	*Number of scats*	*Number of scats containing remains of*				*Weasel hair*
		Peromyscus	*Microtus*	*Small birds*	*Red squirrel*	
Den No. 1	215	148	51	16	—	28
Den No. 2	44	29	15	1	—	6
From trails	35	12	17	3	3	2
Totals	294	189	83	20	3	36
Percentage frequency in all scats		*98.3*	*28.2*	*6.8*	*1.0*	*12.3*

unusual, since most animals preen their coats and so may injest their own hair. Cannibalism is not suspected but may occur under some conditions.

More than one kind of item often was represented in a single scat.

Bird feathers were found in 6.8 per cent of the scats, and weasel hair in 12 per cent. In volume, however, bird feathers considerably exceeded the amount of weasel hair. Great care was needed to find weasel hair as it usually occurred in very small amounts.

The remaining 240 scats were composed (air dry weight) of bone and teeth, 11.06 per cent; hair, 21.9 per cent; and feathers, .01 per cent. The residual (67.03%) seemed to be dirt, fat, and waste tissue from the food digested by the weasels. All of the bones were in small fragments seldom exceeding 2 mm. in length. Incisors and molars of *Microtus* and *Peromyscus* were found, the former more commonly; both genera were represented by quantities of hair.

The food habits of the weasels studied were considered to be more beneficial than harmful to agriculture and to wildlife. Mice constituted the greatest portion of the diet, song birds a very small part, and game birds even less. No losses of game mammals or furbearers were observed.

Evidence supporting the popular opinion that weasels are blood suckers was lacking. Much hair and feathers enter their digestive systems as shown by the scat analyses. This indicates that flesh is eaten in quantities large in proportion to the size of the predators, and it is concluded that weasels are not blood suckers.

During analysis of the droppings, careful watch was kept for traces of shrews and moles, because of controversy in the literature that they are obnoxious to weasels. No recognizable traces of them were found.

SUMMARY

In one year weasels were reported to have killed 1.03 per cent of all chickens in one township in Michigan. They inflicted 59 per cent of the total damage to poultry by all forms of wildlife. Weasels were known to have entered 19 per cent of the chicken coops on the study area.

Farmers killed 68 per cent of the weasels seen on farms during that year, although no bounty was paid as an incentive. Weasels invade barn areas mainly during the spring and early summer.

As furbearers, weasels locally afford a lower total annual income than any other species.

The winter food habits of weasels are beneficial to agriculture, since many mice are eaten. The selection of food items was roughly 65 to 70 per cent *Peromyscus*, 23 to 33 per cent *Microtus*, and 2 to 7 per cent of small birds. No significant damage to game species during the winter months was found.

No reliable method of censusing was obtained.

The home range of each weasel was about 300 acres, and the average cruising radius 0.3 mile from the den. The average daily travel distance is somewhat less than 2 miles.

Each weasel used only one den throughout the winter. Individuals may remain in dens for periods of two or three days. Both weasels and mink were active during the coldest winter weather.

BRIEFER ARTICLES

WATERFOWL BROOD COUNTS IN MANITOBA, SASKATCHEWAN, AND ALBERTA, 1935, 1938–42

The More Game Birds in America Foundation organized and conducted the first ground and aerial survey of waterfowl population in western Canada during 1935. The surveys have been repeated by Ducks Unlimited (Canada) from 1938 to 1942, inclusive. The brood counts have been abstracted and summarized from the tally sheets of the ground surveys (Table 1).

Several hundred observers took part in

TABLE 1.—BROOD TOTALS AND AVERAGES FOR CANADIAN DUCKS

	Females with Broods	Total Young	Average Brood	Females with Broods	Total Young	Average Brood	Females with Broods	Total Young	Average Brood
	1935			1938			1939		
SURFACE FEEDERS									
Mallard	48,140	284,025	5.90	36,714	257,869	7.02	42,452	251,825	5.93
Black duck[a]	—	—	—	39	354	9.07	22	135	6.83
Pintail	14,648	93,380	6.37	10,379	60,168	5.7	17,237	103,963	6.03
Shoveller	7,421	48,185	6.49	10,206	60,560	5.8	6,222	35,946	5.77
Baldpate	1,682	10,628	6.32	1,669	10,297	6.1	3,197	17,075	5.34
Gadwall	1,251	7,869	6.29	2,212	14,806	6.67	2,155	15,235	7.07
Blue-winged teal	—	—	—	3,525	23,728	6.7	7,237	52,906	7.31
Green-winged teal	—	—	—	1,599	12,013	7.5	5,818	44,610	7.67
Teals (unidentified)	25,324	148,739	5.87	9,889	55,442	5.5	3,183	19,574	6.11
Totals and averages	98,466	592,826	6.09	76,232	495,237	6.49	87,523	541,269	6.18
DIVING DUCKS									
Redhead	2,028	11,742	5.79	695	4,117	5.9	3,293	19,439	5.9
Canvasback	5,940	28,357	4.79	5,932	33,439	5.6	5,198	31,068	5.97
Lesser scaup	5,746	41,010	7.14	2,248	15,016	6.6	3,133	12,882	4.11
Ruddy duck	211	1,182	5.6	175	960	5.4	222	1,004	4.52
Bufflehead	5,135	30,784	5.99	1,362	7,566	5.7	481	2,424	5.04
American golden-eye	771	5,037	6.53	804	4,125	5.1	475	2,445	5.15
Ring-neck	—	—	—	8	49	6.1	159	565	3.61
Scoters[b]	827	4,285	5.18	1,145	6,802	5.93	1,550	7,965	5.14
Totals and averages	20,658	122,397	5.92	12,369	72,074	5.82	14,511	77,792	5.36
MERGANSERS[c]	—	—	—	430	3,099	7.2	87	472	5.4
UNIDENTIFIED	32,575	188,699	5.8	13,960	55,385	3.97	12,292	62,698	5.10
Grand totals	151,699	903,922	5.96	102,991	623,795	6.05	144,432	682,277	5.96
	1940			1941			1942		
SURFACE FEEDERS									
Mallard	8,120	50,921	6.27	9,107	58,181	6.4	9,856	56,782	5.7
Black duck	10	70	7.0	—	—	—	7	49	7.0
Gadwall	841	4,332	5.15	524	2,840	5.4	461	2,529	5.5
Baldpate	611	3,507	5.73	526	3,253	6.2	579	3,163	5.5
Green-wing teal	539	3,341	6.17	829	5,350	6.5	1,261	7,046	5.6
Blue-wing teal	1,292	8,400	6.5	1,397	9,300	6.7	2,146	11,551	5.4
Teals (unidentified)	3,060	18,691	6.10	1,639	10,650	6.5	1,679	9,854	5.9
Pintail	5,226	32,334	6.18	3,350	21,817	6.5	4,923	24,109	4.9
Shoveller	3,036	17,933	5.92	2,388	14,502	6.1	2,845	15,784	5.5
Totals and averages	22,735	139,529	6.14	19,760	125,893	6.4	23,757	130,867	5.5
DIVING DUCKS									
Redhead	334	2,042	6.11	373	2,657	7.1	1,057	5,883	5.6
Canvasback	1,950	12,784	6.55	1,381	9,028	6.5	1,850	12,037	6.5
Ring-neck	60	369	6.15	19	96	5.0	18	69	3.8
Scaup	1,545	9,693	6.27	687	3,959	5.8	997	6,450	6.5
American golden-eye	416	2,729	6.56	502	2,895	5.8	118	809	6.8
Bufflehead	347	2,024	5.84	155	922	5.9	87	528	6.1
Scoters	600	4,038	6.56	234	1,223	5.2	267	1,506	5.6
Ruddy	106	553	5.21	83	303	3.7	68	351	5.2
Totals and averages	5,358	34,232	6.39	3,434	21,083	6.1	4,462	27,633	6.19
MERGANSERS	—	—	—	65	204	3.1	34	343	10.1
UNIDENTIFIED	—	—	—	1,218	7,975	6.5	1,876	10,147	5.4
Grand totals	28,093	173,761	6.18	24,504	155,452	6.3	30,129	168,990	5.61

[a] Breeding records confined to Manitoba, western limit of its range.
[b] Probably all, White-winged but some American and Surf scoters may be included, as the name "black duck" is used commonly in northern Saskatchewan and Alberta.
[c] Commonly recorded as "fish ducks" or "sawbills"; segregation by species not attempted.

the count each year; a few were amateur and professional ornithologists, but the majority were farmers and sportsmen with a better-than-average knowledge of waterfowl. In compiling the figures we have eliminated any estimates or guesses so far as these could be detected. A majority of the counts were made in the agricultural areas of the three provinces and represent a large scale random sample of waterfowl productivity as it appears in the last week in July each year.—B. W. CARTWRIGHT, *Ducks Unlimited (Canada), 201 Bank of Commerce Chambers, Winnipeg, Canada.*

INJURIES TO YOUNG TREE TRUNKS FROM ANTLER RUBBING BY DEER

The damage to tree reproduction resulting from browsing by deer is well known in forests where the population of these animals is large. In many cases a so-called "deer line" results. Less noticeable but also of interest are the injuries inflicted on young tree stems by deer rubbing with their antlers. Trees thus injured are occasionally encountered in all New England forests and become frequent in sections where white-tailed deer (*Odocoileus virginianus*) are abundant.

During the summer of 1942 one of the authors had excellent opportunity to observe the results of deer rubbing in the Great Mountain Forest in Norfolk and Canaan, Connecticut. This forest consists primarily of hemlock-hardwood and mixed hardwoods, mostly over 40 years old, and supports a large deer population. Trees with injured stems are scattered throughout but are particularly common along deer trails. The conditions provided by old charcoal hearths seem to be very attractive to deer and many rubbed trees are found in such situations. The attractiveness of old hearths may result from the lesser density of the forest vegetation they support, or the relatively level and slightly elevated surface which they present, or peculiarities in the chemical composition of the vegetation. Mitchell and Hosley (Black Rock Forest Papers 1 (5): 24–27, 1936) found preferential browsing on plots fertilized with nitrogen in the Black Rock Forest.

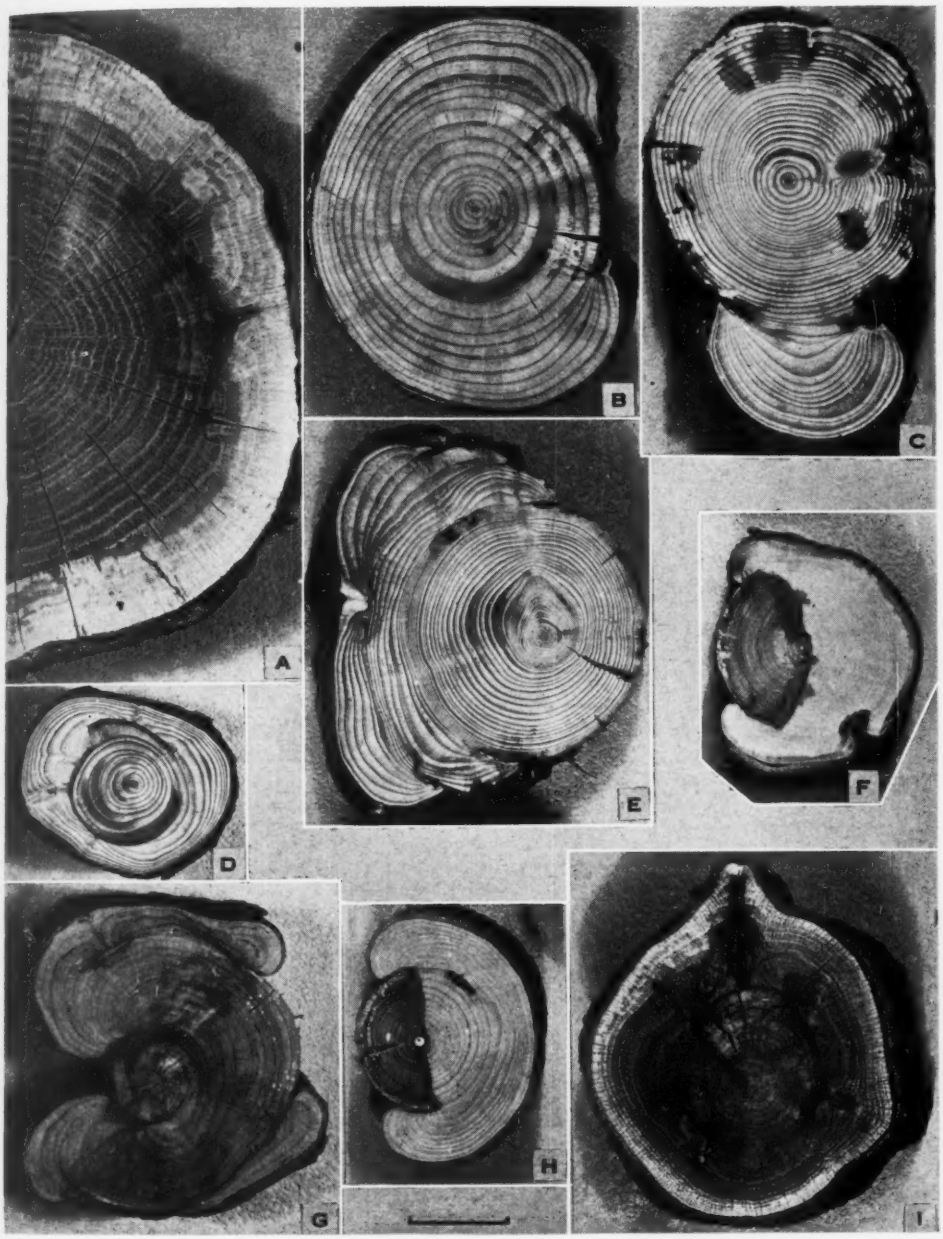
A survey of the Great Mountain Forest, in April, 1943, by students in the Yale School of Forestry, showed that trees injured by deer rubbing occurred on about 13 per cent of nearly 500 quarter-acre plots. The percentage with one or more injured trees varied from 24 to 5.

Injuries from rubbing are caused only by bucks. The development of their antlers is complete by August, but the velvet remains. By mid-September the antlers are scraped clean and polished. During the time that velvet is being shed, and for a period thereafter, the bucks rub on selected young trees, thereby removing or damaging the bark and other tissues external to the xylem.

All species of forest trees were affected; there was no evidence of distinct preferences. Dissection and measurements of over 50 stems of various species indicated that the average age of trees when injured was about 22 years, but varied from 11 to 60 years. The average diameter of the stems at the time of injury was about 1.5 inches, ranging from 0.5 to 4.7 inches. Most of the trees examined were in the understory which accounts for their relatively small size in relation to age. The oldest were over-topped red spruce (*Picea rubens*) and the largest were dominant red oaks (*Quercus borealis maxima*).

In general, the wounds were at a height of about 20 inches (10 to 36 inches). The lowest point of injury was usually about 12 inches and the highest point about 32 inches above the ground. One basswood (*Tilia americana*) 2.0 inches in diameter was wounded to a height of 50 inches above the soil surface. The average maximum circumference injured was about 45 per cent, but variations were large. One white pine (*Pinus strobus*) about 1.0 inch in diameter at breast height had 87 per cent of its circumference damaged. Occasional stems are completely girdled.

Injuries resulting from deer rubbing are easily identified. The bark is shredded along the vertical axis of the wound and usually bears evidence of having been torn away at the top and bottom. Furrows made by the antlers are common in the bark and occasionally extend into the xylem. In the material examined, wounding always occurred



Injuries to tree stems resulting from rubbing by deer antlers. (Scale at the bottom represents 1 inch.) *A*. Red oak wounded 6 years previously. *B*. White pine wounded 6 years ago. *C*. Red spruce wounded 15 years ago. *D*. Hemlock (*Tsuga canadensis*) wounded twice, 8 and 9 years ago. *E*. Red spruce wounded three times, 13, 6, and 4 years ago. *F*. Red maple (*Acer rubrum*) wounded 4 years ago. *G*. Striped maple (*Acer pennsylvanicum*) wounded twice, 14 and 4 years ago. *H*. White ash (*Fraxinus americana*) wounded 8 years ago. *I*. Red oak wounded twice, 13 and 12 years ago.

after late (summer) wood formation was completed. The position of the wounds on the stems also is quite characteristic.

Narrow wounds, covering only a small percentage of the stem circumference of rapidly growing trees, may be healed quickly (Pl. 5, *A*). Discoloration of the wood occurs in most cases and decay occasionally is evident. Large wounds heal more slowly and in most species decay is certain to enter (Pl. 5, *F, G, H, I*). Trees having wood not resistant to attack by fungi suffer the most. Thus, wounded basswood stems are often reduced to mere shells owing to destruction of the heartwood by decay. Large wounds which are not healed quickly weaken the stems and render them liable to breakage by wind, snow, ice glaze, or other natural agents. The wood of injured spruces is rather resistant to decay and is commonly pitch-soaked (Pl. 5, *C*).

Some trees die within a few years after being wounded but many continue to live; if the injuries are serious and decay enters before healing is completed, as frequently occurs, the stems can never be expected to produce anything but fuelwood or other products of low value.—H. J. LUTZ AND H. H. CHAPMAN, *School of Forestry, Yale University, New Haven, Connecticut.*

A COURSE IN "WINTER WOODCRAFT"

There is a distinct need to train many wildlife students and others how to live outdoors with a minimum of equipment and yet attain a maximum of comfort. "Woodcraft may be defined as the art of getting along in the wilderness by utilizing nature's store house. . . . Real woodcraft consists rather in knowing how to get along without the appliances of civilization than in adapting them to wildwood life" (Kephart). Probably there is no unanimity in choice of a term that best describes this training. The term "woodcraft" is not inclusive enough if men are to be trained for a wide variety of habitats. Kephart (1906) recognized this and wrote: "We need a generic term to express the art, in general, of getting on well in wild regions, whether in forests, deserts, mountains, plains, tropics or arctics; and for this I suggest the plain English compound wildcraft." The term was used by Whelen (1927) in the title of his book, "Wilderness Hunting and Wildcraft."

To meet western conditions, the forestry school of Utah State Agricultural College offered a new course in January, 1942, which attempted to meet some outdoor situations of living harmoniously and understandingly with the environment. Unfortunately, many of the topics listed below could be touched only briefly, and all students criticized the class as being too short (one lecture and one outdoor laboratory per week) and in being given for only one season (winter). Part of it could advantageously be presented at the annual summer camp of the forestry school.

The topics are outlined together with names of authors who contribute most fully to each; other reference works deal with some of the subjects.

WILDCRAFT

1. Clothing. a. General seasonal considerations (Kephart); b. Articles (Kephart, White, Stefansson, Whelen).

2. Beds. a. Types (Kephart, Mason); b. Blankets (Kephart, Whelen); c. Bed rolls (Kephart, Mason).

3. Camping accessories (Hanks, Kephart, Mason, Miller, Parks, White).

4. Fires. a. Fundamentals (Mason); b. Types (Kephart, Hanks, Mason, Seton); c. Bank oven; d. Camp stoves (Miller).

5. Tents. (Kephart, Mason, Whelen, White).

6. Temporary shelters other than tents. a. Forest types (Mason, Kephart, Hanks); b. Snowhouse (Stefansson).

7. Snow. a. Characteristics (Seligman); b. Avalanches (Seligman, Rybizka).

8. Skis (Schneibs, Rybizka, Lang, Schneibs and McCrillis, Proctor and Stephens). Snowshoes (Greig, Hunt).

9. Weather signs. Wind (Albright, Blair).

10. Nature lore. a. Tracking (Seton); b. Bird and mammal identification (Anthony, Paul, Peterson).

11. Hunting methods (Whelen). a. Deadfalls and snares (Harding, Gibson); b. Guns (Askins, Whelen); c. Bow and arrow; d. Sling.

12. First aid generalities (American Red Cross Manual). a. Outdoor pests (Kephart); b. Poisonous plants (Muenscher); c. Physical well being (Graham and O'Roke).

13. Emergency foods (Hedrick, Rogers).

14. Food list for short trips (Kephart, Frederick, Hanks, Miller, White).

15. Finding one's way (Kephart, Miller, Whelen, Stefansson). a. Reading maps; b. Telling time, compass and sun; c. Telling direction, watch and sun; d. Star identification; e. Topographic knowledge.

16. Axmanship (Anon. 1938, Mason, Kephart).

SOURCE MATERIAL

ALBRIGHT, JOHN G. 1939. Physical Meterology. New York, Prentice-Hall, Inc. xxvii+392 pp., 244 fig.

ANTHONY, H. E. 1928. Field Book of North American Mammals. New York, G. P. Putnam's Sons. xxv+625 pp., illus.

AMERICAN RED CROSS. First Aid Manual.

ANONYMOUS 1939?. Northern Rocky Mountain Scale of Wind Velocity. North Rocky Mt. Forest and Range Exp. Sta.

ANONYMOUS 1938. Woodsmanship for the Civilian Conservation Corps. (Forestry Div., C.C.C.) 15 pp.

ANONYMOUS 1937. Selection of a Snowshoe Model. Nature Magazine, 29: 62, illus.

BEARD, DANIEL C. 1919. The Field and Forest Handy Book. New York, Charles Scribner's Sons. xiv+428 pp., illus.

BEARD, DANIEL C. 1920. The American Boys' Handybook of Camp-Lore and Woodcraft. Philadelphia, J. B. Lippincott Co., viii+270 pp., illus.

BLAIR, THOMAS H. 1937. Weather Elements. New York, Prentice Hall, Inc. xv+401 pp., 107 fig.

BROWN, L. 1929. Make Your Own Snow Snowshoes. Popular Mechanics, 41: 316–319, illus.

CANE, EDWARD. 1919. The Boys' Camp Book. Garden City, Doubleday, Page & Co. xi+194 pp., illus.

1919. The Boy Scouts' Hike Book. Garden City, Doubleday, Page & Co. xv+243 pp., illus.

ENOCK, C. R. 1918. Pioneering and Map Making for Boy Scouts and Others. London, C. Arthur Pearson, Ltd. 120 pp., illus.

GIBSON, H. W. 1911. Camping for Boys. New York, Associated Press. 294 pp., illus.

GIBSON, WILLIAM H. 1876. The Complete American Trapper. New York, James Miller. 300 pp., illus.

GRAHAM, S. A., and E. C. O'ROKE. 1943. On your own. Minneapolis, Univ. Minn. Press. 150 pp., illus.

GREIG, H. W. 1933. Making Snow Shoes. Industrial Arts, 22: 386–389, illus.

HANKS, CHARLES STEDMAN. 1906. Camp Kits and Camp Life. New York, Charles Scribner's Sons. xii+259 pp., illus.

HARDING, S. R. 1907. Deadfalls and Snares. Columbus, Ohio, S. R. Harding. 218 pp., illus.

HEDRICK, U. P. 1919. Sturtevants' Notes on Edible Plants. New York Agric. Exp. Sta. 686 pp.

HOLM, INGRID. 1936. Skiing—A Handbook for Teachers. Troy, N. Y. Russell Sage College. 114 pp., illus.

HOUGH, EMERSON. 1915. Out of Doors. New York, D. Appleton and Co. 301 pp.

HUNT, W. B. 1937. Alaskan Eskimo Snowshoes. Industrial Arts and Vocational Education, 25: 327, illus.

JAEGER, ELLSWORTH. 1929. How to Know Foot Prints. Natural History, 44: 226–232.

JENNISON, GEORGE M. 1938. The Appalachian Scale of Wind Velocity. Appalachian Forest Experiment Station, Asheville, N. C. Technical Note No. 29.

KEPHART, HORACE. 1910. The Book of Camping and Woodcraft. A guide book for those who travel in the wilderness. New York, Outing Publishing Co. xiv+331 pp., illus.

1919. Camping and Woodcraft. 2 vols. New York, The Macmillan Co. 479+405 pp., illus.

1910. Camp Cookery. Columbus, Ohio, Outing Publishing Co. xvi+153 pp.

LANG, OTTO. 1936. Downhill Skiing. New York, Henry Holt and Co. 84 pp., 30 pls.

MASON, BERNARD S. 1939. Woodcraft. New York, S. S. Barnes & Co. vi+580 pp., 295 figs.

MERRILL, L. F. 1933. Snowshow Making Is Easy. Popular Science, 122: 68–69, illus.

MILLER, WARREN H. 1918. Camping Out. New York, George H. Doran Co. 322 pp., illus.

MUENSCHER, WALTER CONRAD. 1939. Poisonous Plants of the United States. New York, The Macmillan Co. xvii +265 pp., illus.

MUYBRIDGE, E. 1909. Animals in Motion. Illus. New York, Chas. Scribner's Sons.

O'CONNOR, JACK. 1939. Game in the Desert. New York, Derrydale Press. xx+298 pp., illus.

PALMER, E. LAWRENCE. 1942. Outdoors Living. Penna. Game News, 12(11): 8–9. (Feb.)

PAUL, J. H. 1911. Out of Doors in the West. Salt Lake City, Utah, Skelton Publ. Co., 260 pp.

PETERSON, ROGER TORY. 1941. A Field Guide to Western Birds. Boston, Houghton Mifflin Co. xxiii+240 pp., illus.

PRAGER, WALTER. 1939. Skiing. New York, S. S. Barnes and Co. 92 pp., illus.

PROCTOR, CHARLES N., and ROCKWELL R. STEPHENS. 1936. Skiing. New York, Harcourt, Brace & Co. xv+109 pp., illus.

RYBIZKA, BENNA. Avalanches. National Ski Patrol, 415 Lexington Ave., New York, N. Y. Mimeo.

SCHNEIBS, OTTO EUGEN. 1939. American Skiing. New York, E. P. Dutton & Co. 232 pp., illus.

SCHNEIBS, E., and JOHN W. MCCRILLIS. 1936. Modern Ski Technic. Toronto, McLeod Publ. Co. 119 pp., photos.

SELIGMAN, G. 1936. Snow Structure and Ski Fields. New York, The Macmillan Co. 555 pp.

SETON, ERNEST THOMPSON. 1911. Rolf in the Woods. New York, Grosset Co. xv+437 pp., illus.

SETON, ERNEST THOMPSON. 1911. Two Little Savages. New York, Doubleday, Page and Co. xiv+552 pp., 29 plates, 200 figs.

STEFANSSON, VILHYALMUR. 1921. The Friendly Arctic. New York, The Macmillan Co. 784 pp., illus.

WHELEN, TOWNSEND. 1927. Wilderness Hunting and Wildcraft, with Notes on the Habits and Life Histories of Big Game Animals. Marshallton, Del., Small Arms Technical Publishing Co. x+338 pp., illus.

WHELEN, TOWNSEND. 1940. The Hunting Rifle. Harrisburg, Pa., Stackpole Sons. 463 pp., 88 figs.

WHITE, STEWART EDWARD. 1907. Camp and Trail. New York, Lothrop, Lee & Shepard Co. xi+236 pp., illus.

—GEORGE HILLS KELKER, *Utah State Agricultural College, Logan, Utah.*

CHEMICAL ANALYSES OF ORGANS FROM LEAD-POISONED CANADA GEESE

Lead poisoning in waterfowl has been a recognized disease for at least forty years. Much has been written on the subject and some chemical analyses have been made to determine the presence of lead in waterfowl, but these have been chiefly qualitative. Wetmore (U. S. Dept. Agric. Bull., 793, 1919) reported the lead content of the caeca of several mallard and pintail ducks, and Magath (Mayo Clinic, Proc. Staff Meeting, 51: 749–752, 1931) that of the bones and liver of lead-poisoned ducks. It was felt that a quantitative study of the concentrations in various organs of lead-poisoned waterfowl would help in understanding the disease better and to establish a conclusive method of diagnosis in doubtful cases.

Four lead-poisoned Canada geese (*Branta canadensis canadensis*) were found on the shore of Swan Lake, near Portage, Wisconsin,

[1] Drs. T. T. Chaddock, Wisconsin Conservation Department, G. R. Hartsough, and R. M. Scott made the postmortem examinations and gave helpful suggestions; Warden George Johnson provided the specimens for analysis.

in April, 1940; two were dead; the others were unable to fly and walked with difficulty.

Upon postmortem examination, all lesions typical of lead poisoning were observed. The liver was enlarged with greenish discoloration and disintegration. The gizzard lining appeared ulcerated and was easily torn. The caeca were dark colored. There was distinct enlargement of the kidneys and spleen. The feces were watery and greenish colored. The gizzards contained lead shot in varying stages of wear. One goose (no. 3) showed less severe lesions but had an unhealed and infected shot wound in the breast. Samples of the organs and bones were removed, weighed, dried, and saved for analysis.

For control purposes, two Canada geese from the State Experimental Game and Fur Farm were killed and samples taken and prepared as before. They had been in captivity for at least a year and were supposedly free from lead poisoning. Postmortem examination revealed no lesions of lead poisoning, but, analysis later showed that they had been exposed to lead poisoning prior to capture. They were not, therefore, true controls, but the analytical results are given for comparison with geese suffering from active poisoning.

The colorimetric dithizone method for determination of lead as given in the *Methods of Analysis of the Association of Official Agricultural Chemists* (4th ed., 375–393, 1935) was used in all analyses. Results of the analyses are shown in the Table 1. Specimens 1 to 4 are the lead-poisoned geese and A and B the captives. Numbers 1, 2, 4, and B were males, and numbers 3 and A were females. The leg bones used in each case were the tibia and fibula. Individual weights of geese are not given as a criterion of size because of the emaciation attendant on lead poisoning. A truer comparison of sizes is obtained from the weights of the leg bones.

The captive geese evidently had been ex-

TABLE 1.—LEAD-POISONED CANADA GEESE

Specimen No.	1	2	3	4	A	B
Condition	Dead	Dead	Alive	Alive	Alive	Alive
Number of Shot	81	11	3	40	0	0
Amount of Lead (milligrams)						
Leg bones	1.3	1.5	1.1	1.8	.40	.72
Liver	2.5	1.3	.73	1.2	.000	.042
Kidneys	1.2	—	.33	.78	.042	.000
Spleen	.04	.04	.0	.08	.077	.077
Lungs	—	.30	.0	.32	.000	.000
Caeca	—	—	—	.34	.157	.000
Heart	—	—	—	—	.000	.000
Concentration of Lead (parts per million)						
Leg bones	67	89	79	98	30	38
Liver	27	20	9	16	0	1
Kidneys	57	—	12	30	6	0
Spleen	23	22	21	73	192	8
Lungs	—	9	2	8	0	0
Caeca	—	—	—	83	18	0
Heart	—	—	—	—	0	0
Comparative Weights of Organs (grams)						
Leg bones	19.3	16.8	13.9	18.3	13.3	19.1
Liver	92.0	64.4	80.4	75.0	20.0	31.6
Kidneys	21.0	—	27.1	26.2	7.2	11.8
Spleen	1.7	1.8	1.9	1.1	.4	.9
Lungs	—	33.6	—	—	23.3	32.5

posed to lead poisoning at some time before they were captured and had overcome the active disease. This is shown by the comparatively high lead content of the bones in contrast to that of the organs. The lead present in the liver, kidneys, spleen, and caeca probably resulted from the release of stored lead from the bones and elimination through these organs. This is a well-known phenomenon in connection with lead poisoning in mammals, and doubtless occurs also in birds.

The amount of lead in the leg bones showed no correlation with the number of shot found in the gizzard. This quantity is rather a measure of the length of exposure to the poisoning, since only a small portion of the daily intake of lead is stored, the bulk of it being excreted. On the other hand, as would be expected, there was some correlation between the lead content of the liver and kidneys and the number of shot present. The concentration of lead in these organs is dependent chiefly on the quantity of lead taken into the system, and only to a small extent on the release of stored lead from the bones.

The spleen and lungs exhibited no correlation in lead content. In fact, one captive goose showed a higher lead concentration in the spleen than any of the lead-poisoned geese. There seems to be no logical explanation of this fact, other than that lead was being released from the bones and concentrated in the spleen during elimination.

A comparison of sizes of organs is given in Table 1 to show the hypertrophy incident to lead poisoning. All weights are on a fresh basis. Using the leg bone weights as a means of size comparison, and assuming the captive geese to be normal as to weights of organ, the amount of enlargement can be estimated. The livers are approximately three times normal size, the kidneys two to three times, and the spleens from slightly over normal to four times normal size.

From a consideration of the data on lead concentrations, it would appear that the best organ to choose for chemical analysis in aiding diagnosis would be the liver. If lead were still being ingested, it would be found in that organ whereas an analysis of the bones at the same time would indicate whether or not the poisoning was chronic.—FREDERICK E. W. ADLER, *Experimental Game and Fur Farm, Wisconsin Conservation Department, Poynette, Wis.*

SEX RATIOS AND COLOR PHASES IN TWO RACES OF RUFFED GROUSE[1]

It is difficult to determine the sex, age, and color phase of ruffed grouse (*Bonasa umbellus*) in their natural habitat, and as few of the birds have been live-trapped, there have been few studies on sex ratios and color variations in this species. The importation of wild grouse from Canada and Wisconsin into Ohio has afforded an excellent opportunity to collect data on these subjects.

Sexual dimorphism is slight. Allen (1934) distinguishes the female as being slightly smaller, with a distinctly shorter tail, a pinkish-brown breast not crossed by short black or brown feathers of the forepart of the ruff (as occurs in the male), and by having the black tail band interrupted on the two central feathers (continuous band on male).

The geographic range of the gray ruffed grouse (*B. u. umbelloides*) extends south from Mackenzie through the Rocky Mountain valleys and east to the western edge of the Great Plains. The range of the Canada ruffed grouse (*B. u. togata*) includes extreme southern Canada and the extreme northern tier of states, east of the Rocky Mountains (Bent, 1932).

Dichromatism occurs in both races and has been reported in others, but one phase seems to predominate in each race. Most writers recognize dichromatism and intergradations between the two phases throughout the range of the species, but none has supplied a detailed description of each phase or what constitutes an intermediate.

[1] Contribution from Pittman-Robertson Wildlife Restoration Projects 4R and 7D, Ohio Division of Conservation and Natural Resources. Floyd B. Chapman, Sterling S. Dietz, Edwin P. Rinehart and others of the Ohio Division of Conservation tabulated much of the material here incorporated; Lee S. Roach, also of the Division, and H. T. Gier of Ohio University gave helpful advice.

TABLE 1.—COLOR AND SEX OF GROUSE STOCKED IN OHIO

Race	Season	Number Stocked	Color phases (percentages)					
			Red		Intermediate		Gray	
			Males	Females	Males	Females	Males	Females
Canada grouse (*B.u. umbelloides*)	1939–40	385	18	17	7	7	29	22
	1940–41	31	13	16			32	39
	1941–42	320	18	11	10	12	28	21
	Total and Averages	736	16	15	9	10	30	28
Wisconsin grouse (*B.u. togata*)	1940–41	38	13	19			42	26
	1941–42	106	9	32	22	17	14	6
	Total and Averages	144	11	28	22	17	28	16

Investigations in New York during 1931–33 showed an average of 51 per cent males to 49 per cent females, and Bump (1932), in the same state, found the sex ratio equal among grouse in favorable cover.

MATERIALS AND METHODS

During the late autumn and winter of 1939 to 1942, wild-trapped grouse were released in Ohio. From Babcock, Wisconsin, 144 were released in the counties of Athens, Vinton, and Washington. From Lacombe, Alberta, Canada, 736 were stocked in the counties of Athens, Hocking, Jackson, Jefferson, Lawrence, Monroe, Morgan, Noble, Ross, Scioto, Vinton, and Washington. Resident Ohio grouse occur in all the areas stocked.

Save for about 50 released in the winter of 1941–42, all grouse were banded, sexed, and classified as red, intermediate, or gray. The amount of rufous or gray markings in the upper coverts and tail feathers was used as the most satisfactory criterion. Sex differentiation was based upon the work of Allen (1934). The first 417 of the Canadian grouse were also sorted as adults and juveniles, using the shape of the two outer primaries as the principal criterion (Wright and Hiatt, 1943). This method seemed satisfactory because all of the immature individuals probably had acquired the first winter plumage when examined—October 16 to April 20.

COLOR RATIOS

The data presented involve study of 385 grouse during 1939–40, 69 during 1940–41, and 426 during 1941–42 (Table 1). In the first two seasons the birds were examined by various individuals in the Conservation Division, chiefly S. S. Dietz and Floyd B. Chapman. The writer examined those stocked in 1941–42.

SEX RATIO

Considering combined ages and colors, there was only a slight disparity of sexes, the predominance of males being slightly greater in the Canadian grouse (114 males:100 females). In the Wisconsin birds, however, there was a noticeable predominance of females of the red phase and of males in the gray phase indicating the possibility of sex linkage or sex influence of color (Table 1).

Study of sex ratios on a montly basis showed a rise in the comparative number of males during the late autumn and then a gradual decrease. In April the sexes were nearly equal. A survey of the literature has failed to reveal any idiosyncrasies of the ruffed grouse that might result in unequal susceptibility of the sexes to trapping. Furthermore, the grouse from widely separately areas show the same average proportion of males to females even though the two races differed on a monthly basis.

AGE

Immatures and adults occurred in nearly equal numbers when figured on the basis of an entire winter season. In general, the adults gradually decreased from November through April (Table 2). The larger number of immatures received during October may be explained in part by the "fool-hen" characteristics of the younger birds and their lack of suspicion of bird traps.

Of the October immatures 57 per cent were females; the sex ratio was still about the same (150 males:100 females) in April. October adults approached the same sex ratio as autumn immatures, but there was an unusually large number of old males in April, 4 per female. If this is representative, some unknown factor decimated the adult female population. Nevertheless, the higher percentage of immature females tended to offset the "shortage" of old female grouse. Accordingly, an April ruffed grouse population of 100 individuals would consist of 16 adult males, 32 immature males, 4 adult females, and 48 immature females, totalling 48 males and 52 females.

DISCUSSION

Very little information is available on dichromatism in the ruffed grouse, especially involving a large number of birds. Bent (1932), Forbush (1912), Roberts (1932), and Todd (1940) all discuss its occurrence in this species but either base their contentions on relatively small series or fail to mention the numbers studied.

Of the gray ruffed grouse in Manitoba, Seton (1885) stated that only about 20 per cent were pure *umbelloides*, the true gray form, and that about 10 per cent of the birds have copper ruffs. In the current study there was over twice the proportion of gray grouse noted by Seton. Only 2 per cent of all imported Canadian birds had brownish ruffs and half of these were pure *umbelloides*. Red, intermediate, and gray color phases exhibited nearly equal sex ratios in birds received from Canada.

Bent (1932) stated that *B. u. togata* is typically one of the races in which "the red phase is rare and less pronounced." Our data on Wisconsin grouse reveal that the red and gray phases are about equally divided; however, these birds were trapped in one locality and may not be typical of the whole range. Since these birds came from the center of the state, I am inclined to agree with a suggestion of Todd (1940) for Minnesota that the "gray phase will be found in greater numbers in the northern part of the state, and the rufous phase in the southern," but not an indiscriminate mixture of red and gray birds (over the state) as indicated by Roberts (1932). Forbush (1927) reported that intermediates were "typical" northern ruffed grouse (*B. u. togata*). Slightly over one-fourth of the 144 birds we examined were in this classification. Unlike the Alberta grouse, there was a preponderance of females in the red phase (67%) and males in the gray (66%); the intermediates more closely approached a balanced sex ratio (Table 1).

Leopold (1933) claims that "a marked disturbance of sex ratio may be considered as circumstantial evidence of disease"; our data indicate that over the period covered, limiting factors, including disease, had the same effects on both sexes.

The ratio of adults to juveniles changed drastically between October and April. King (1937) reported an October grouse population

TABLE 2.—CANADIAN RUFFED GROUSE: COMPARISON OF IMMATURES AND ADULTS BY SEXES

Month	*Numbers of Birds*	*Percentages*					
		Immatures			*Adults*		
		Males	*Females*	*Totals*	*Males*	*Females*	*Totals*
October	91	26	36	62	18	20	38
November	28	25	14	39	40	21	61
December	215	22	26	48	33	19	52
January	52	12	33	45	33	22	55
April	31	32	48	80	16	4	20
	Means	**23**	**31**	**54**	**28**	**18**	**46**

during normal years with 57 per cent immatures. Our Canadian material for October 1939 included 62 per cent immatures (Table 2). Bump (1930) reported that in New York there is an over-all winter die-off of 33 per cent. Calculations from data by King (1937) on a limited census area in Minnesota show that 51 per cent of the autumn population died before spring, including the allowable take and the expected winter fatalities. Our figures show that the April population consists of 80 per cent immatures. If we can assume an average winter die-off of 40 per cent based upon the reports of Bump (1930) and King (1937), then during an average winter there is a reduction of 3.4 adults to 1 immature. In other words, not over 20 per cent of the individuals might be expected to live through two winters, or to exceed the age of 22 months!

SUMMARY

Data are given on sex ratios, color phases, and adult-juvenile ratios of 880 live-trapped ruffed grouse, involving two subspecies, released for stocking purposes in 12 unglaciated counties of Ohio.

Canadian birds were primarily of gray individuals; those from Wisconsin of the red or rufous phase, with the grays next in numbers. Nearly twice as many were intermediate in the Wisconsin stock as in that from Canada. Both races showed about equal sex ratios for combined age classes and color phases, although there were slightly more males in the latter case.

Despite differences in winter trapping methods in the two areas, the total average sex ratios were nearly identical; therefore, over long periods, the sex ratios in the ruffed grouse taken by trapping were about equal.

Calculations based upon this work, previous papers, and those of other investigators reveal that 80 per cent of the wild ruffed grouse population does not exceed the age of 22 months.

LITERATURE CITED

ALLEN, A. A. 1934. Breeding season behavior of the ruffed grouse. Amer. Game Conf. Trans., 20: 311–323.

Anonymous. 1934. New York, Conserv. Dept. Ann. Rept., 23 (1933), Legislative Document No. 38: 262–267.

BENT, A. C. 1932. Life histories of North American gallinaceous birds. U. S. Nation. Mus. Bul., 162: 141–178.

BUMP, GARDINER. 1930. Ruffed grouse studies. Amer. Game Conf. Trans., 17: 207–210.

1932. The New York ruffed grouse survey. Amer. Game Conf. Trans., 19: 388–403.

FORBUSH, E. H. 1912. A history of the game birds, wildfowl and shorebirds of Massachusetts and adjacent States. Boston, Mass., Wright & Potter Printing Co. pp. 377–384.

1927. Birds of Massachusetts and other New England States. Norwood Mass., Norwood Press. 2: 26–37.

KING, RALPH T. 1937. Ruffed grouse management. Journ. Forestry, 35: 523–532.

LEOPOLD, ALDO S. 1933. Game management. New York, Charles Scribner's Sons. pp. 112, 339.

ROBERTS, T. S. 1932. Birds of Minnesota. Minneapolis, Univ. Minn. Press.

SETON, E. T. 1885. Notes on Manitoban birds. Auk, 2: 267–271.

TODD, W. E. CLYDE. 1940. Eastern races of the ruffed grouse. Auk, 57: 390–397.

WRIGHT, PHILIP L. and ROBERT W. HIATT. 1943. Outer primaries as age determiners in gallinaceous birds. Auk, 60: 265–271, 1 pl.

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APPRAISAL OF PORCUPINE DAMAGE[1]

Among the commonest causes of forest injury are fire, disease, insects, mammals, birds, and climate. When any agency injurious to forest growth does not completely destroy the growing stock, the appraisal of total damage, both current and subsequent, is complicated and difficult to calculate accurately. This is largely because the forest does not always become understocked as a

[1] The aid of D. B. Demeritt, Department of Forestry, University of Maine, in the computations is gratefully acknowledged.

result of their activities even though quality value is lowered, and secondary injurious agencies follow in the wake of the primary ones. Mammals and birds are likely to produce partial damage to both trees and forest stands. Some aspects of partial damage appraisal have been discussed previously (Curtis, 1941).

PORCUPINES

Perhaps the most important mammal from the standpoint of injury to forest trees is concerned is the porcupine (*Erethizon* spp.). Much has been written about the damage that results from porcupine feeding, but there appears to have been little attempt made to determine the damage on a financial basis although this is desirable from the standpoint of forest management. This work is an effort to correlate population of porcupines and damage, to which, it is hoped, more information can be added subsequently from New England and from other parts of the country where porcupines are found in sufficient numbers to justify similar investigations.

Taylor (1935) states that the animal is found " . . . with certain outstanding exceptions, throughout the forested area of the continent of North America, mainly in Hudsonian, Canadian and Transition Zones." Consequently in any scheme of forest management included in the above territory, feeding on forest trees can be expected.

The feeding habits and preferences of this animal apparently vary regionally. For example, the bark and leaves of gray birch (*Betula populifolia*) are rarely taken in southern New England (Sudworth, 1927), but often in Maine. The animals show a preference for one species over another depending on those available. In Maine, northern white cedar (*Thuja occidentalis*), hemlock (*Tsuga canadensis*), and beech (*Fagus grandifolia*) are the most favored, but in Massachusetts, sugar maple (*Acer saccharum*) and basswood (*Tilia glabra*) are selected. Ponderosa pine (*Pinus ponderosa*) is favored in the Southwest, and northern white pine (*Pinus strobus*) in the Lake States. Since porcupines appear to be able to seek out their preferred foods, the frequency and abundance of tree species do not prevent the most desirable kinds from escaping damage but do influence the volume of food available.

The gnawing of bark is the most injurious form of feeding by porcupines. This is certainly true when an attempt is made to estimate loss in money value; removal of branches from hemlock and northern white cedar often produces coarse and stag-headed trees, but such damage is difficult to appraise.

It is essential to know the number of porcupines causing injuries to determine if there is correlation between their numbers and the amount of damage to the growing trees. Taylor (1935) reports estimated populations of three to fifteen per square mile in Arizona and New Mexico; the Deschutes National Forest in Oregon supports fewer and the Tusayan National Forest in Arizona more. Reeks (1942) estimates about six to eight per square mile in New Brunswick, Canada.

METHODS

The counts here described were made in areas typical of large red spruce regions in Maine (Hawley *et al.*, 1931) on relatively level land. These are "moderately well-drained to poorly-drained flats but not true swamps, well-drained slopes though not on the best soils, [and] thin-soiled upper slopes." The species, in decreasing order of abundance, include: balsam fir (*Abies balsamea*), red spruce (*Picea rubra*), northern white cedar, white spruce (*Picea glauca*), white birch (*Betula papyrifera*), northern white pine, eastern hemlock, largetooth aspen (*Populus grandidentata*), Norway pine (*Pinus resinosa*), red maple (*Acer rubrum*), beech, and yellow birch (*Betula lutea*). Alder swales with little or no tree growth are present in varying amounts.

Complete censuses were made in Washington County on two 320-acre areas about two miles apart by senior students under supervision. The men were spaced about 50 feet apart and moved forward in a line (1,320 feet long), guided by the end men who traveled blazed compass lines. This obviated the use of compasses by the intermediate men. The presence of porcupines was determined by tracks, scats, or pruned foliage on fresh crustless snow, some 24 hours after a

fall. When any fresh signs were evident, all the men were stopped by a shouted signal passed along the line. When an animal was located another prearranged signal would again start the line. An accurate and slightly conservative population figure was obtained for some 320 acres in four hours.

After censusing, the areas were cruised by the line-plot method for total volume and damaged volume on lines five chains apart, and ¼-acre sample plots were measured at 10-chain intervals. Red spruce, balsam fir, and Norway and white pines were the only species present and salable when the cruise was made and only these were tallied.

One method of estimating porcupine damage is to assume that the salable timber will be cut within a year or two. This considers the results of feeding activity to date and its effect on the marketable products. The trees tallied included all spruce and fir 6 inches or more d.b.h. (diameter breast high) and all white and Norway pines 10 inches d.b.h. or larger. All were examined for feeding scars. For spruce, the diameter at the small end of the injured four-foot bolt was noted separately, and for pines the height and number of scars and the heights of the trees were recorded. All scars on trees were ascribed to feeding by porcupines unless there was evidence to the contrary. Since many spruce bolts having scars are used by the pulp companies unless there is much rot or a large amount of pitch evident, the estimate of damage probably was high.

The total volume of spruce in cords was calculated by the usual method of volume tables, and the culled volume was calculated from the number and size of individual bolts. Since Norway pine is sold and graded with white pine in the area studied, these two species were treated together; the cruised volume and culled volume were calculated by taper curves and application of the Maine log rule.

RESULTS

Area A contained 14 animals (28 per square mile), and Area B had 10 (20 per square mile). These numbers are higher than those estimated by Taylor and Reeks, showing that populations will vary, depending on many factors which are imperfectly understood. Lacking repeated censuses, there is no way to know how stable these populations are; they probably are influenced largely by food and, to a lesser extent, by shelter and natural enemies.

The results of these cruises, and of a third cruise in a spruce bog type (Area C) in Penobscot County, were as follows:

	Areas		
	A	*B*	*C*
Porcupines per square mile	28	20	—
Damage per acre			
Spruce	$.038	$.047	$.360
Pine	.087	.110	—
Totals	.115	.157	.360
Losses in percentage of total volume per acre	*.51*	*.53*	*2.40*

The total losses per acre from porcupine feeding varied between 11.5 and 36 cents per acre, but the latter figure is not typical of general conditions because the spruce bog swamp type does not support a sufficient volume of spruce and pine to justify profitable operations. The only other accurate estimate of financial loss from porcupines known to the writer is that by Hunter (1918), using a similar method of appraisal with lodgepole pine (*Pinus contorta*) in northwestern Colorado; his figures were $0.45 to $1.10 per acre and represented the difference between salable green and porcupine-killed trees.

In the present study the method used to calculate loss was the change in log length made necessary by the presence of scars. Another method would be to ignore the scars, cut logs in the usual lengths, and compute the lowering in value from the boards sawed. This might be more accurate but is difficult to follow through.

CONCLUSIONS

The census in this study was accomplished by 18 men on Area A and 17 on Area B in four hours on each. The cost per square mile would, therefore, be about $50.00. An ideal time for such a census is about 24 hours after a fall of powdery snow when the animals have had time to move around and to feed. Each man must understand his role completely and perform it implicitly.

Estimation of the damage to merchantable stumpage can be recorded when any area is cruised in the ordinary manner with a slight increase in time. Some modification might be necessary depending on the sort of country cruised, but would be preferable to guess work.

Inasmuch as the stated losses resulted from the feeding to date, it is questionable if any costs for protection could be justified, unless volume increment per acre was substantially higher than the estimated average of 0.10 cord of spruce and fir per acre per year. Since porcupines return to trees on which they have fed previously, particularly hemlock, larch (*Larix laricina*), and sugar maple, it is possible that a system of silvicultural treatment to retain these and perhaps some other "weed" species would supplement a management plan and ultimately be cheap, sufficiently practical as to losses, and attuned to biological control which is believed by many ecologists to be the most desirable in forest management.

LITERATURE CITED

CURTIS, J. D. 1941. The silvicultural significance of the porcupine. Jour. Forestry, **39**: 583–594.

HAWLEY, R. C., *et al.* 1931. Forest cover types of the eastern United States. Report of the Committee on Forest Types. Washington, D.C., Soc. Amer. Foresters.

HUNTER, G. M. 1918. Porcupines and the damage they do. U. S. Forest Service. Denver, Colo. 10 pp. *MS.*

REEKS, W. A. 1942. Notes on the Canada porcupine in the Maritime Provinces. Forestry Chronicle, **18**: 182–187.

SUDWORTH, G. B. 1927. Check list of forest trees of the United States. U. S. D. A. Misc. Cir., **92**.

TAYLOR, W. P. 1935. Ecology and life history of the porcupine (*Erethizon epixanthum*) as related to the forests of Arizona and the Southwestern United States. Univ. Arizona, Biological Science Bull., **3**.

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PARASITES OF THE BLUE GROUSE[1]

This study is based on specimens of the blue grouse (*Dendragapus fuliginosus*) obtained in Washington, northern Idaho, and northwestern Montana from September 1939 to May 1941. Of the 128 birds used, 127 were examined for internal and 115 for external parasites.

MALLPHAGA

Degeeriella perplexa (Kell. and Chap.). An adult male sooty blue grouse (*D. F. fuliginosus*) taken April 1 in Cowlitz County, Washington, had 92 lice of this species, but they did not seem any injury other than minor irritation.

Lagopoecus lyurus Clay. This louse infested one of 111 Richardson blue grouse (*D. o. richardsoni*). The host was captured in Okanogan County, Washington and kept alive at Pullman, Washington, for several months before it died of injuries. The captivity and the general weakness of the bird probably accounted for the large infestation.

DIPTERA

Ornithomyia anchineura Speiser. This fly appeared on one *richardsoni* from Okanogan County, but should not be considered a regular parasite. Kenneth MacArthur (in letter) stated that this louse fly restricts its parasitic activities mostly to passerines, having been taken from at least 38 species; there is one record from a bobwhite quail in the eastern United States. To his knowledge this in the only record from a gallinaceous bird in the United States, save for the blue grouse.

NEMATODA

Heterakis gallinae (Gmelin) Freeborn. One *richardsoni* taken in Okanogan County, Au-

[1] Part of a cooperative study by the State College of Washington and Washington Department of Game; includes some material collected by the Idaho Department of Fish and Game and the Montana Game Department. Aid in identification of parasites was given by Allen McIntosh and E. E. Wehr, U. S. Bureau of Animal Industry; H. E. Ewing, U. S. Bureau of Entomology and Plant Quarantine; and Kenneth MacArthur.

gust 9, 1940, when about 10 weeks old, had 12 of these roundworms in its caeca, but the latter showed little or no signs of irritation.

Cheilospiura sp. This parasite of the gizzard lining appeared in four *richardsoni* from Okanogan County; three (one an adult) yielded one each and another had five. Even these small numbers caused considerable injury to the gizzard wall, especially near the opening between the proventriculus and ventriculus.

CESTOIDEA

Tapeworms were the most abundant parasites found and may be responsible for much of the high juvenile mortality noted in the Okanogan region. They infested the young more heavily than the adults.

Raillientina sp. These worms infested 13.7 per cent of the *richardsoni* examined; one bird yielded 53, but the average was nine. Nearly all of the worms were in the duodenum.

Rhabdometra nullicollis Ransom. This species appeared in 43.5 per cent of the *richardsoni* examined; four of *fuliginosus* had none. One grouse had 93 of this species. They inhabited the small intestine below the duodenum, and were the most important parasites found during the study.

DISCUSSION

Most of the birds were collected during the summer and autumn; 59 were young and 62 were birds of the first autumn. They included grouse from less than two weeks old to adult breeding birds and gave a cross section which may be useful in guiding future studies of the blue grouse populations.

Of the sooty grouse, two from Thurston County, and one from Clark County, Washington, showed no parasites. Among the Richardson grouse, one from Asotin County, Washington, one from Latah County, Idaho, and five from Lincoln County, Montana, had none.

Parasites infested juvenile or immature birds more than adults, both as to number and severity of infestation; 61 per cent of the young and 43 per cent of the adults were parasitized by one or more species. Only the young showed definite irritation or injury to the digestive tract and general emaciation. The condition of the bodies did not make adequate autopsies possible, but a number of young grouse found dead probably died from parasitism.

The tapeworms *Rhabdometra nullicollis* and *Raillietina* sp. appeared in two birds estimated to be but 12 and 16 days old, respectively. Because the parasites were well developed, they must have been picked up when the chicks were only a few hours old.

One immature female was in such a weakened condition that she was caught easily by hand. She died a few hours after capture and autopsy revealed a heavy infestation of *R. nullicollis*. The 93 tapeworms present filled the intestine almost completely, and had caused severe injury. The bird weighed but 60 per cent of the normal for her age.

The severity of infestations probably weakened many young birds so much that they became easy prey for predators—at least this explanation fits field evidence of predation losses. Each parasite usually appeared in a limited area of the host, and little mingling appeared in the digestive tract.—JAMES BEER, *2904 Harney Street, Vancouver, Washington.*